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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

L. H. DONNELL, *Editor*

T. VON KÁRMÁN, S. TIMOSHENKO, *Editorial Advisers*

I. GENERAL

General Theoretical and Experimental Methods 185

II. MECHANICS OF SOLIDS

1. Dynamics

General Dynamics, Kinematics, Friction . 186
Gyroscopics, Governors, Servomechanisms 186
Vibrations, Balancing 186
Wave Motion, Impact, Seismology . . 187
Acoustics 188

2. Primarily Elastic Behavior

Elasticity Theory 188
Experimental Stress Analysis 188
Rods, Beams, Shafts, Springs, Cables, etc. 189
Plates, Disks, Shells, Membranes . . . 190
Buckling Problems 191
Joints and Joining Methods 192
Structures 192

3. General Behavior

Plastic Flow, Failure; Mechanics of Solid State 193
Design Factors, Meaning of Material Tests 194
Material Test Techniques 195
Mechanical Properties of Specific Materials 195
Soil Mechanics; Seepage 196

III. MECHANICS OF FLUIDS

Potential or Laminar Incompressible Flow 196
Turbulence, Boundary Layer, etc. . . . 197
Compressible Flow, Gas Dynamics . . 197
Aerodynamics of Flight; Wind Resistance 199
Aeroelasticity (Flutter, Divergence, etc.) . 200
Propellers, Fans, Turbines, Pumps, etc. . 200
Experimental Flow Equipment and Technique 200
Lubrication; Wear 200
Dynamics of Meteorology and Oceanography 201
Ballistics; Detonics (Explosions) . . . 201

IV. HEAT

Thermodynamics 201
Heat Transfer 201

List of Periodicals Now Being Regularly Scanned . . . 202

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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

July 1948 Vol. 1, No. 7

General Theoretical and Experimental Methods

(See also Rev. 1155)

1078. **M. L. Bihovski, "Accuracy of mechanisms controlled by ordinary differential equations"** (in Russian), *Bull. Acad. Sci. USSR Ser. tech. Sci.* (*Izv. Akad. Nauk SSSR Ser. tekh. Nauk*), Nov. 1947, no. 11, pp. 1455–1512.

This is an unusually painstaking paper (it is asserted that a systematic and general error analysis of mechanisms is confined to the Soviet Union). For the disk-and-wheel integrator 31 sources of error (including, for instance, lubrication film thickness) exist; for the associated screw-and-block 47 of them are listed. The first variation (called "the error" by the author) of the output integral is expressed in terms of the variations of the listed design parameters and the input variables. Of the original 78 variations only 12 turn out to be relevant, and enter into nine integrals of the form $I = \int_{v_0}^{v} \eta u dv$, where v is the variable of integration, and η a random function whose mean value $\bar{\eta} = \eta_i$ and dispersion $D\eta_i$ are constant within each of a set of intervals L_i of the same length Δx.

If the correlation coefficient between the random variables $\eta(x_i)$ and $\eta(x_k)$ is $r(x_1, x_2)$, then the author asserts that $\bar{I} = \int_{v_0}^{v} \bar{\eta} u dv$, $D_I{}^2 = \int_{v_0}^{v} \int_{v_0}^{v} r(x,y)u(x)u(y)D_\eta(x)D_\eta(y)dxdy$. For the case $r(x, y) = \exp[-k|x-y|/(v-v_o)]$, and constant D_y, the author gets

$$D_I{}^2 = 2D_\eta{}^2 (v - v_o)^2/k$$

and regards D_I as negligible, whence the claim that integration suppresses the random errors. The application of this theorem to the variation of the output integral results in a definitive formula for the error of the integrator, and specific suggestions for error reduction (say, elimination of deadlocks).

Bold generalizations follow a description of the Bush-type analyzer. They culminate in a statistical error theorem for systems of differential equations: For a system of the type $\phi_k(y^{(n)}, \ldots, y', y, \eta, \ldots) = 0$, involving a number of given η-functions, the mean value of each y (neglecting second-order quantities) is the integral of this system, with the η's and the initial values replaced by their mean values; and the dispersion D_y of y (neglecting second-order terms again) is given by $D_y{}^2 = \Sigma(\partial y/\partial \eta_i)^2{}_o D_{\eta i}(\Delta x)$, where the subscript o indicates the mean value, and η_i the mean value of η in the i-th interval. If the ϕ_k's are linear in the $y^{(i)}$'s and η's, these relations hold rigorously. The same claim that D_y is negligible is made. A. W. Wundheiler, USA

1079. **E. E. Weibel, N. M. Cokyucel, and R. E. Blau, "A mechanical analyzer for the solution of vibration problems of a single degree of freedom,"** *J. appl. Mech.*, June 1948, vol. 15, pp. 146–150.

The authors describe a torsion pendulum type of mechanical analyzer suitable for the approximate solution of certain types of nonlinear, nonhomogeneous ordinary differential equations. It is particularly convenient for one-degree-of-freedom vibrational problems with some types of nonlinear damping, some types of nonlinear spring force, and any reasonable forcing function.

Two applications are discussed: (1) The graphical records of the amplitude during acceleration of a system through resonance are presented at three different amounts of damping. (2) The results of a complete analysis of the effect of a single square-wave pulse forcing function on a system with linear-plus-cubic spring characteristic and viscous damping are given. The probable error in the second example is estimated at ±4 per cent in amplitude ratio and ±10 per cent in force amplification ratio.

Stanley Corrsin, USA

1080. **V. G. Gheorghiu, "A new method of measuring friction coefficients (Sur une nouvelle méthode de mesure des coefficients de frottement),"** *Bull. Ec. polyt. Jassy*, July-Dec. 1947, vol. 2, pp. 200–206.

A new method for simultaneous measurement of two coefficients of friction is described. The rubbing surfaces are constituted by three test specimens, one specimen being common to two pairs of surfaces, the frictional forces on it being balanced. No experimental data are given, so that it is not possible to judge the merits of the method. H. Blok, Holland

1081. **H. F. Schiefer, "Measurement and elimination of inertia effects in textile testing equipment by means of electric strain gages,"** *Amer. Soc. Test. Mat. Bull.*, no. 150, Jan. 1948, pp. 43–45.

This paper describes the inadequate results which will be obtained when rapid tests are made in a machine which has a weighing system of low natural frequency. This is demonstrated by placing a high-frequency dynamometer in series with the low-frequency pendulum of a standard textile testing machine. Variations in the inertia forces and in the rate of loading are shown by graphs in the paper.

A new textile testing machine being constructed for the National Bureau of Standards is described. The load and extension measuring devices are fully automatic. No mention is made of the natural frequency of these measuring devices, but presumably they are low, for the measuring is done by balancing the inductances in a Wheatstone-bridge circuit.

Evan A. Davis, USA

1082. **W. G. Bickley, "Finite difference formulae for the square lattice,"** *Quart. J. Mech. appl. Math.*, Mar. 1948, vol. 1, pp. 35–42.

For use in the numerical solution of partial differential equations, this paper develops a number of refined approximations for derivatives and integrals of a function of two variables. The formulas are based upon values of the function at the nodes of a square net. Principal emphasis is given to the expression approximating the Laplacian operator; two refinements of the usual Liebmann formula are developed and the magnitude of the error

for each is discussed. These refined formulas require the inclusion of four more nodal points than the Liebmann formula. The refinements are advocated not for the initial coarser nets, but for final stages of the calculations on a fine net, in order to obtain increased accuracy without further reducing the net spacing.

Several formulas for the integral over an area of a function of two variables are given in addition to those based on the two-dimensional form of the trapezoidal rule and of Simpson's rule. No numerical examples of the use of any of the formulas are given.

Dana Young, USA

General Dynamics, Kinematics, Friction

(See also Revs. 1078, 1080, 1155)

1083. R. H. Scanlan, "An analytical study of the landing shock effect on an elastic airplane," *J. aero. Sci.*, May 1948, vol. 15, pp. 300–304.

The paper is concerned with the determination of the accelerations of the components of an elastic airplane, given the time history of the forcing functions applied to the main landing gear in vertical and drag directions. No aerodynamic forces are taken into account. Degrees of freedom considered are: wing bending (two modes), wing torsion (two modes), fuselage vertical bending, landing-gear bending, stabilizer bending, airplane free-body translation, and pitch (seven in total). Generalized co-ordinates are introduced by the use of uncoupled modes of the considered parts of the airplane. (The employed modes are stated to be "coupled normal modes," but the reviewer is unable to discover any trace of couplings.)

Equations of motion are established by the Lagrangian principle and a formal method of solution is indicated. Damping is introduced in the end, in the equations referring to normal co-ordinates of the complete system, essentially by admitting out-of-phase elastic restraints (hysteresis damping). No applications or examples are given. J. H. Greidanus, Holland

1084. P. D. Ladopoulou, "On the mobility of polyhedra" (in Greek with summary in French), *Bull. Soc. math. Grèce*, 1947–1948, vol. 13, nos. 1, 2, 3, pp. 51–126.

The author has discovered a connection between rigidity (and mobility) of plane or spatial linkages and a familiar concept of projective geometry. His results can be presented conveniently if the following definition is introduced: "Two polygons are side-conjugate if their sides can be paired so that each pair intersects on the same straight line." Similar definitions hold for the terms: "vertex-conjugate," and "face-conjugate." The Desargues theorem states the two triangles that are side-conjugate are vertex-conjugate, and conversely. We shall call a polygon Desargues'ian if it is vertex-conjugate to every polygon to which it is side-conjugate, and vice versa. A similar definition holds for polyhedra.

One group of the author's results can now be stated as follows: "Polygons and polyhedra are rigid if, and only if, they are Desargues'ian." It follows easily that projective transformations preserve the property of rigidity. The author proves further that a polyhedron N has the same type of mobility (i.e., is rigid, infinitesimally or finitely mobile) as the solid angle obtained by putting edges and faces parallel to those of N through a point of the space. Further, a solid angle has the same type of mobility as its plane polygonal cross sections. It follows that closed polyhedra must be rigid and that finite and infinitesimal mobilities are affine invariants.

These results are generalized for noneuclidian geometries. Applications to octahedrons of Bricard and Mannheim are given.

A. W. Wundheiler, USA

1085. A. K. Nikitin, "On some properties of the trajectories of a conservative system" (in Russian), *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*), Jan.-Feb. 1948, vol. 12, pp. 23–28.

If all $H_{p_i} = 0$ at a point of a solution of the canonical equations $\dot{q}_i = H_{p_i}$, $\dot{p}_i = -H_{q_i}$, with $H = \text{const}$, the trajectory has a cusp on a fixed surface of the q-space. Some other similar remarks are made. A. W. Wundheiler, USA

Gyroscopics, Governors, Servomechanisms

(See Rev. 1154)

Vibrations, Balancing

(See also Revs. 1094, 1097, 1131)

1086. J. Haag, "On vibrators with stable amplitude (Sur les **oscillateurs à amplitude stabilisée),"** *C. R. Acad. Sci. Paris*, May 19, 1947, vol. 226, pp. 1567–1568.

This note is concerned with the study of the properties of the solution of the equation $\ddot{\theta} + \omega^2\theta = -2\omega\dot{\theta}g(y)F(\theta, \dot{\theta})$ where $y = (\theta^2 + \dot{\theta}^2/\omega^2)^{1/2}$. It is demonstrated that if the functions g and F are subject to certain restrictions, the variable θ executes stable oscillations. Louis A. Pipes, USA

1087. E. Pinney, "Aerodynamic oscillations in suspension bridges," *J. appl. Mech.*, June 1948, vol. 15, pp. 151–159.

This paper deals in a fairly complete manner with the theoretical determination of the dynamic and flutter characteristics of suspension bridges. The bending and torsion modes of vibration of a symmetrical suspension bridge, having two towers and side spans, are determined by means of the principle of virtual work in which the elastic energies are considered for the bending and torsional forces of the roadbed, the tension in the cables, and the bending and torsional forces in the towers. The towers are assumed to be hinged beams which are replaced by members having equivalent, linear and rotational, stiffnesses and mass distributions at the top.

The aerodynamic forces of the Theodorsen type for an oscillating flat plate, modified to include the effect of roadbed "slats," are then incorporated in the equations of motion. These equations are solved to determine the flutter velocities and frequencies. Applications of these results are made to the Tacoma Narrows Bridge which failed in a high wind some years ago. The results are indicated by structural damping versus wind velocity curves for various tied and untied conditions of the cables. It is shown that the theoretical results agree with the observed behavior of the bridge, and that there is satisfactory agreement between predicted and observed flutter speeds and frequencies. M. V. Barton, USA

1088. R. D. Mindlin, F. W. Stubner, and H. L. Cooper, "Response of damped elastic systems to transient disturbances," *Proc. Soc. exp. Stress Anal.*, 1948, vol. 5, no. 2, pp. 69–87.

The author calculates the flexural vibrations of a cantilever bar whose clamped end is subjected to a half-sine-wave pulse, and checks his results by experiments. Taking the solution for

no damping from the literature, a modification of the differential equation is considered, which was proposed by Sezawa in 1927 and introduces damping as a linear function of strain rate in the form $\sigma = E\epsilon + c(\partial\epsilon/\partial t)$. The modified equation is then solved.

Both solutions check the experimental results closely in the range $\omega/p_1 < 3(\omega = \pi/T$ being the frequency of the disturbing force, T the duration of the disturbance, and p_1 the first natural frequency of the bar). For shorter disturbances the theory of undamped vibrations yields (as expected) too large strains, while Sezawa's theory makes them too small, since critical damping in structural materials is known to be independent of the frequency, and not proportional to it.

As there is not much hope of finding solutions for other damping laws, the authors propose a semiempirical method, in which cp_n (p_n being the frequency of the nth mode) is replaced by a constant after solving Sezawa's equation. Damping thus becomes independent of the frequency, and the mathematical and experimental results are then in good agreement.

Heinz Parkus, Austria

Wave Motion, Impact, Seismology

(See also Revs. 1083, 1088)

1089. **C. E. Crede and S. E. Young, "Theoretical and experimental investigation of buckling shock mount,"** *Proc. Soc. exp. Stress Anal.*, 1948, vol. 5, no. 2, pp. 144–153.

The shock mount which is the subject of this paper has a hollow cylindrical rubber element with a wall of nonuniform thickness. Under a load parallel to the axis of the cylinder, the mount buckles, the load remaining practically constant during buckling. The mount is studied under an instantaneous-velocity-change shock in the buckling direction.

A family of curves gives the relations found between the velocity change, the ratio of buckling force of the mount to the load being carried, and the height of mount for optimum performance. Another family gives the maximum acceleration of the shock-mounted body under these optimum conditions.

The maximum accelerations of components of the mounted equipment have been used to define optimum performance of the shock mount. It has been tacitly assumed by the authors that these accelerations can be computed with sufficient accuracy by using only the first half cycle of the acceleration-time curve of the shock-mounted equipment. J. Paul Walsh, USA

1090. **V. A. Sveklo, "Plane waves and Rayleigh waves in an anisotropic medium"** (in Russian), *Notes Acad. Sci. USSR (Doklady Akad. Nauk SSSR)*, Feb. 11, 1948, vol. 59, pp. 871–874.

For the system of the two partial equations with constant coefficients

$$\Sigma a_{\alpha\beta}{}^{pq}\, u_{\alpha\beta}{}^{q} = u_{tt}{}^{p}, \quad p, q, \alpha, \beta = 1, 2,$$

the solution

$$u^p = \Sigma \int^{\Omega k} A_k{}^p(t)\, w_k(t)\, dt, \quad k = 1, 2, 3, 4$$

is stated. Here the w's are arbitrary, $A_k{}^1$, $A_k{}^2$ are a set of minors of the determinant $|\Sigma_{\alpha,\beta} a_{\alpha\beta}{}^{pq}\, m_\alpha m_\beta - \delta^{pq} l^2|$, where δ^{pq} is Kronecker's symbol, and l, m_1, m_2 are chosen to annul the determinant. Ω is any function of t, x_1, x_2, constant on the characteristic planes $lt + m_1x_1 + m_2x_2 = \text{const}$, of which there are four families. This solution generalizes the familiar plane waves. It is applied to determine, in a nonisotropic medium, the reflection of a plane wave from a plane, free face. The analog of the Rayleigh function and waves is thereby discovered.

A. W. Wundheiler, USA

1091. **W. H. Hoppmann, "Impact of a mass on a damped elastically supported beam,"** *J. appl. Mech.*, June 1948, vol. 15, pp. 125–136.

This is an analytical study of the deflection and bending stress produced by central impact of an elastic body on a freely supported beam having an elastic foundation of negligible mass. Internal and external damping of the beam is considered. To avoid the more exact but laborious step-by-step process of Timoshenko, a solution is obtained by assuming a variation of impact force with time compatible with conditions of change of momentum. The expression involves the coefficient of restitution and the impact time. The former is derived from two somewhat complicated factors, representing the energy imparted to, and that absorbed by damping in, each mode of beam vibration during the impact.

Cases in which the beam may, for practical purposes, be considered to have one degree of freedom are considered. Calculations are given for steel spheres striking centrally a steel beam for various foundation constants (damping zero) and various damping conditions (foundation constant zero). The question of subimpacts is ignored. R. N. Arnold, Scotland

1092. **P. Groen, "Two fundamental theorems on gravity waves in inhomogeneous incompressible fluids"** (in English), *Physica Hague*, June 1948, vol. 14, pp. 294–300.

The equations of the unsteady motion of an incompressible medium in which the density is a function of the depth are derived in terms of the stream function. Thus, with the restriction to two dimensions, the differential equation for small gravity waves is found. Then the condition is introduced that the flow has two plane parallel walls at different heights as boundaries. The period of the waves is dependent upon the number of nodal planes in the vertical direction, and upon the wave length in the horizontal direction. It is first shown, in a general way, that for a fixed number of nodal planes the period is a monotonic increasing function of the wave length. It is next shown that all the possible periods have a lower limit which is inversely proportional to the square root of the maximum of the vertical density gradient. Gottfried Guderley, USA

1093. **D. Laugharne Thornton, "Impact loading of structures,"** *Engineering*, Apr. 30, 1948, vol. 165, pp. 409–412.

The effect of rapid loading on the mechanical properties of various materials of construction is discussed on the basis of the results of recent impact tests on steel.

The equations of motion expressing the propagation of elastic strain waves by extensional and flexural vibrations in a bar are given and the physical meaning of the expressions is interpreted.

Equations are also derived for the semielastic or plastic waves which occur when the proportional limit of a material is exceeded due to deformation occurring at a rate greater than the permissible velocity of impact for elastic deformation. The physical interpretation of these results is also discussed and a need for further investigation is noted. Equations are derived and curves are given showing the change in shape of the pulse due to partial reflection and partial transmission when it meets an appreciable change in the cross section or in the mechanical properties of the material. Nicholas Di Pinto, USA

Acoustics

(See also Rev. 1136)

1094. I. Barducci, "Specific mechanical impedance of tubes with small cross sections (Impedenza meccanica specifica dei tubi di piccola sezione)," *R. C. Accad. Lincei*, Apr. 1947, vol. 2, pp. 431–437.

The author investigates the acoustic impedance of tubes of cross section small in comparison to the length of sound waves. Besides the reactance of the mass of air in the tube, the author considers the effect of viscosity, as well as that of thermal conduction. Radiation effects are neglected. For tubes of circular cross section the specific mechanical resistance (acoustic resistance per unit cross section of the tube) and the specific mechanical mass (acoustic reactance per unit cross section) are given by

$$R_s = \bar{\nu}\varphi M_s' x^2/r^2,\ M_s = \psi M_s',\ M_s' = \rho l,\ x = r(\omega/\bar{\nu})^{1/2} \ldots [1]$$

(r is the radius of tube, $\bar{\nu}/2.18$ is the kinematic viscosity). The resistance coefficient φ and the mass coefficient ψ have been expressed in terms of Bessel functions of x [*R. C. Accad. Lincei*, 1946, vol. 1, p. 764] by the same author.

For tubes of arbitrary cross section the specific mechanical resistance and specific mechanical reactance are given by

$$R_s = \varphi'(\bar{\nu}l/\rho)(P/2s)^2,\ M_s = \psi\rho l$$

To a first approximation the effect of conductivity on both R_s and M_s is to substitute for ν Kirchhoff's correction $\bar{\nu} = 2.18\nu$, as was done in the case of circular tubes. Equation [1] includes the case when the tubes have rectangular cross sections. Finally the author defines the factor of merit; the tube behaves as a pure resistance for low frequencies and small sections, and as an inductance for large cross sections and high frequencies.

Nicholas Chako, USA

1095. K. A. Velizhanina and S. N. Rzhevkin, "Noise analysis of a moving airplane" (in Russian), *J. tech. Phys.* (*Zh. tekh. Fiz.*), Dec. 1947, vol. 17, pp. 1483–1490.

Propeller and exhaust are the principal sources of airplane noise, and both produce sounds of tonal nature. The noise spectrum is, for many reasons, slightly variable. Current sound analyzers are of limited usefulness for studying it since (1) the exposure times are too long; (2) the weaker components are omitted; (3) the frequency discrimination does not exceed one third of an octave. The authors recommend using any type of recording (wire or film is favored), from which an "almost-period" is extracted and recopied a number of times, the copies being later joined into a sound track of about 0.1 sec duration. If no period can be perceived, any sufficiently long interval can be used, and the authors exhibit the corresponding formulas.

For the study of the Messerschmidt 109 the authors made a phonograph recording, transferred it onto a film, recopied 30 cm of the sound track 14 times, ran the combined strip through a reproducer, and fed the amplifier output into a Rodman analyzer. Two spectra are shown in the paper, one for overhead, the other for receding flight. A. W. Wundheiler, USA

1096. M. Ferrero and G. Sacerdote, "Determination of the parameters of sound propagation in absorbent materials (Determinazione dei parametri di propagazione sonora in corpi assorbenti)," *Nuovo Cim.*, Oct. 1947, vol. 4, pp. 262–274.

In this paper the authors have determined the principal acoustic characteristic parameters (acp) for glass wool and plane waves falling normally on a homogeneous layer of the absorbing material. Further experiments are in progress with other materials. The experimental arrangement is such that the acoustic problem becomes equivalent to an electric transmission line with distributed parameters. However, in the acoustic case, the acp are functions of the frequency. Starting with the transmission-line formula for the impedance, the authors have carried out the analysis for the special case of an open end line (infinite terminal impedance). Taking the ratio of the impedances for two thicknesses of the absorption layer, one being twice the thickness of the other, and by separating the real and the imaginary parts, they obtain, for αl and βl constant,

$$1 \quad \rho \sin 4\alpha l = [2(\cos 2\vartheta - \cos 4\alpha l)]^{1/2}$$

$$2 \quad \rho \sinh 4\beta l = [2(\cosh 4\beta l - \cos 2\vartheta)]^{1/2}$$

(ρ, ϑ) being the polar co-ordinates referred to the center (l, 0), β the damping constant, and α the constant of phase. The results show that the acoustic resistance varies linearly with the frequency, and the equivalent acoustic capacitance is independent of the frequency. The acoustic inductance is also a function of frequency and decreases with increase of frequency more rapidly at lower frequencies. These results are in disagreement with those of Wüst [*Hochfrequenztech. Electroakust.*, 1934, vol. 44, p. 73] who found that both the resistance and the conductance for the same material were constant, the capacity being a function of the frequency, decreasing from 1×10^{-6} to 0.71×10^{-6}. The present authors obtained a constant value of 0.785×10^{-6}.

Nicholas Chako, USA

Elasticity Theory

(See also Revs. 1090, 1102, 1103, 1105, 1110, 1115, 1128)

1097. C. Gurney, "The effective stress concentration at the end of a crack in materials having atomic constitution," *Phil. Mag.*, Jan. 1948, vol. 39, pp. 71–76.

The author calculates an approximate average value of the circumferential principal stress in a small region $\Delta \times \Delta$ at the end of an elliptic cylindrical crack. The effective stress concentration defined on the basis of this average value is shown to be $1.1\sqrt{c/\Delta}$ for a crack of length $2c$ and minimum radius of curvature Δ, with a limit of $1.8\sqrt{c/\Delta}$ for a line crack.

It is stated that atomic dimensions become important in all cases where the theory of elasticity predicts infinite stress. In particular, the smallest possible radius of curvature is said to be of atomic size, as is the dimension Δ over which an average should be taken. The author expects that a crack will spread by splitting due to thermal action when the effective stress reaches a critical value.

An elliptic cylindrical crack was chosen instead of an ellipsoidal cavity for reasons of simplicity. It is interesting to note in this connection that Sadowsky and Sternberg [*J. appl. Mech.*, Sept. 1947, vol. 14, pp. 191–201] have found that stress concentrations in a homogeneous body for the case of a prolate spheroidal cavity are of the order of 3 in the limiting case of a line crack, and infinite stress concentration does not appear. D. C. Drucker, USA

Experimental Stress Analysis

1098. J. Ewles and C. Curry, "Cathode-ray recording micrometer and force gage," *J. sci. Instrum.*, Oct. 1947, vol. 24, pp. 261–265.

This article describes a device which makes use of a cathode-ray oscillograph in conjunction with a moving coil system to record and measure rapidly varying movements. An oscillating

current flowing in a first coil induces a current in a moving second coil. The response in the second coil is amplified and fed into the oscillograph, and of course the trace recorded on the screen of this instrument varies with the motion of the coil. The trace width varies linearly with the displacement of the coil, as is shown by a calibration curve obtained for the device. In this manner an instrument results which is sufficiently sensitive to measure a displacement of the order of 3 mm with an accuracy of 0.0025 mm.

The device has a very long range of action, since ample sensitivity can be obtained when the coil system is as much as 1000 yards from the oscillograph recorder. The authors believe, moreover, that both the range and the sensitivity can be improved by varying the frequency of the initial current and some design features. The instrument is compact, being about 3 in. longer and 3 lb heavier than a Cossor cathode-ray oscillograph. A detailed description of the design and construction of the device is given. A recording force gage is also described which makes use of the same principle as the device described above.

The instrument was employed in a set of experiments with rapidly varying shear stress, the results of which are given and discussed. A careful outline of the preparation of the test and of the calibration work is given. The results show that the mean peak force for rapid shear is only slightly in excess of the mean static force. For the particular steel-pin specimen considered, the values of the two forces were, respectively, 251 ± 4 kg and 243 ± 2 kg. Bruno A. Boley, USA

1099. **D. C. Drucker and M. M. Frocht, "Equivalence of photoelastic scattering patterns and membrane contours for torsion,"** *Proc. Soc. exp. Stress Anal.*, 1948, vol. 5, no. 2, pp. 34–41.

The authors give a simple theoretical derivation supported by experiment to show that photoelastic scattering patterns can be obtained which are in every way the same as membrane contours for pure torsion. The methods used are practically the same as previously used by the authors, and by Frigon ["Some three-dimensional studies with scattered light," *Proc. Fifteenth Eastern Photoelastic Conference*, 1941, p. 68]. The experimental results agree quite well with theoretical values. R. M. Wingren, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1091, 1099, 1118, 1120)

1100. **R. A. Williamson, "Torsion-bending stresses in box beams,"** *J. aero. Sci.*, July 1948, vol. 15, pp. 427–434.

A procedure similar to the moment-distribution method is presented for determining torsion-bending stresses in prismatic box beams of rectangular cross section. Examples based on data from Kuhn and Brilmyer's *Nat. adv. Comm. Aero. Wartime Rep.*, no. 91 require somewhat less computation, yet yield values in agreement with the results of that report. Sufficient steps are included in the derivation of the factors required in using the method so that one skilled in the art may extend the procedure to trapezoidal or other shapes of sections.

The procedure is clearly presented and should be of considerable value to stress analysts who can estimate "effective thicknesses" or "effective stiffnesses" for the flat panels composing the sides of the equivalent rectangular beam which replaces the cambered skin panels of the actual airplane wing. Joseph S. Newell, USA

1101. **C. Wets and A. Paduart, "Secondary deflections in metallic ties (Flexions secondaries dans les tirants métalliques),"** *Ossature métallique*, June 1947, vol. 12, pp. 287–294.

The authors analyze the effect of lateral forces or imposed lateral deflections on the stresses in simply supported or built-in tie rods. They integrate the differential equation of the deflection curve.

In addition to many well-known results [such are given in Timoshenko's "Strength of materials," part II, pp. 39–43], several new formulas are derived for cases of tie-rods subjected to symmetrical equally spaced lateral loads. These problems are of importance for certain prestressed concrete beams. A table of the required numerical coefficients is given at the end of the paper. Ch. Massonnet, Belgium

1102. **S. G. Gootman, "General solution of the plane problem of equilibrium of a beam whose outline consists of logarithmic spirals"** (in Russian), *Notes Acad. Sci. USSR (Doklady Akad. Nauk SSSR)*, May 1948, vol. 60, pp. 559–562.

A beam is analyzed whose depth at any point is proportional to the radius of curvature of its axis. This results in boundaries curved to logarithmic spirals. The problem is solved by means of the usual Airy stress function for plane stress, expressed in a curvilinear co-ordinate system adapted to the geometry of the problem. In addition to general expressions for the stress function and the stresses, in terms of biharmonic series, closed solutions are given for the special cases of (1) a moment applied at the pole, (2) a concentrated force applied at the pole.

It is maintained that applications can be made in the field of dams and of crane construction. No numerical data are given, either tabular or graphical, which would enable one to judge the deviations of this exact solution from that obtained by the elementary theory, deviations which should be expected to become significant only for reasonably large ratios of depth to length.
George Winter, USA

1103. **C. B. Smith and A. W. Voss, "Stress distribution in a beam of orthotropic material subjected to a concentrated load,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1486, Mar. 1948, pp. 1–37.

The paper presents an analytical study of the stress distribution in a beam of orthotropic material and of rectangular cross section. In the analysis wood is considered to be orthotropic. The beam is taken to be infinitely long and to be subjected to a periodic normal load on the upper and lower faces. The results are then extended to various types of loading and end conditions for a beam of finite length.

The particular case of a concentrated load on a beam with fixed or simple supports is considered. The stress distributions are expressed in terms of infinite series. A method of reducing the infinite series to the sum of a finite series and a closed form is described.

In addition, the analytically determined distribution of horizontal shear in the vicinity of a concentrated load is compared with the distribution obtained in a test of a Sitka spruce beam of rectangular cross section. Frank Baron, USA

1104. **Beschkine, "Theory of torsion bending of prismatic beams—open profile (Théorie de la torsion-flexion des poutres prismatiques—profils ouverts),"** *Batim. Trav. publics*, Nov. 25, 1947, ser. I, no. 39, pp. 1–15.

In a prismatic beam with an open cross section, axial stresses may be caused not only by an axial force or a bending moment, but also by torsion. The theory of torsion bending is given in this paper for the case when the beam can be considered a membrane without thickness, and when the displacements are infinitely small.

Starting from the equations of equilibrium of a membrane element and taking into consideration the boundary conditions, the author introduces the conception of a "bimoment" B, which facilitates the development of the theory. The bimoment B_α in a cross section with respect to a point O in the cross section is defined by $B_\alpha = 2\int_D \alpha N_2 ds$, where $N_2 ds$ is the normal force on the part ds of the membrane cross section, and α is the area of the sector between O and ds. Using suitable co-ordinates, the author derives expressions for stress distribution, deformation, and elastic stability.

In the case of a symmetric profile the analogy with elementary bending is simplified by the introduction of a so-called "conjugate profile." W. L. Esmeijer, Holland

1105. Jean Mandel, "On the calculation of the center of torsion of a cylinder by means of the reciprocity theorem (Sur la détermination du centre de torsion d'un cylindre à l'aide du théoreme de réciprocité)," *C. R. Acad. Sci. Paris.*, Mar. 8, 1948, vol. 226, pp. 779–781.

The author implicitly defines the shear center of an isotropic cylinder as that point through which a terminal transverse load must be applied in order that the twisting function τ of the classical Saint Venant theory of bending should be zero. This definition depends on Poisson's ratio, and is the same as that adopted by Goodier [*J. aero. Sci.*, July 1944, vol. 11, pp. 272–280], but differs from that proposed by Trefftz, Weinstein, and others, in which the term involving Poisson's ratio does not appear [see, for example, A. Weinstein, *Quart. appl. Math.*, Apr. 1947, vol. 5, pp. 97–99].

It is suggested that the formulas given are of particular value in the case of thin-walled tubes such as airplane wings. However, since the cross sections of such tubes are generally constrained against distortion by diaphragms, the reviewer's opinion is that the simpler definition of Trefftz is more appropriate. In any case the difference is too small to be of technical importance although it is of academic interest. P. C. Dunne, England

1106. E. Volterra, "On the general problem of an elastically supported beam, Parts I, II (Sul problema generale della trave poggiata su suolo elastico)," *R. C. Accad. Lincei*, 1947, vol. 2, Mar., pp. 307–311; Apr., pp. 418–421.

In the first part of his paper the author, by means of the Fourier transform, solves the problem of the infinitely long uniform beam on an elastic foundation, for the very general case that the influence function of the foundation's deflection is of the kind $k(x - \xi)$. The general expression for the beam's deflection is

$$y(x) = (I/\sqrt{2\pi}) \int_{-\infty}^{+\infty} Y(u)\, e^{-iux}\, du, \text{ where}$$

$$Y(u) = \frac{P(u)}{EIu^4 + I/[\sqrt{2\pi}K(u)]}$$

$P(u)$ and $K(u)$ are the Fourier transforms of the load $p(x)$ acting on the beam, and of the influence function of the foundation's deflection, respectively.

The author considers in particular the following expressions for the influence function of the foundation's deflection

$$k(x - \xi) = I/\lambda \text{ for } x = \xi,\ K(x - \xi) = 0 \text{ for } x \neq \xi$$

corresponding to Winkler's law, and

$$k(x - \xi) = Ae^{-B(x-\xi)}$$

corresponding to Jodi's law, which is closer to practical applications. A and B are constants of the foundation, which can be determined experimentally [C. Jodi, "Methods for experimental researches on elastic foundations (Procedimenti per ricerche sperimentali su suoli elastici)," *R. C. Accad. Lincei*, 1936, ser. 6].

In the second part the author applies his general solution to the case of a load uniformly distributed over the length $2l$ of the beam. For this purpose he uses a theorem on the calculation of the Fourier transform of a holomorphic function of the complex variable. For Winkler's law he obtains known equations for the beam's deflection, while for the more accurate Jodi's law he determines an expression for the beam's deflection which is analytically similar to the former, and no more complicated. The mathematical treatment of the problem is elegant.

Giulio Ceradini, Italy

Plates, Disks, Shells, Membranes

(See also Revs. 1104, 1111, 1112, 1113, 1114, 1115, 1125, 1137)

1107. R. Grammel, "Solution of the problem of the high bursting strength of rotating disks (Die Erklärung des Problems der hohen Sprengfestigkeit umlaufender Scheiben)," *Ingen.-Arch.*, 1947, vol. 16, no. 1, pp. 1–4.

The observed speed at which a rotating disk bursts corresponds to a maximum hoop stress at the inner radius (calculated by the usual elastic equation), which is greater by a factor of 1.5 to 2.5 than the rupture stress of the material observed in a simple tension test. The author considers the critical speed of a disk to be that at which the hoop stress reaches the critical stress of the material at all points, rather than at the inner radius only. He derives a relation between the speed at rupture and the tensile strength of the material, and from this obtains an expression for the ratio of the hypothetical rupture stress (based on elastic behavior) to the actual tensile strength of the material. The range of this ratio is found to be from 1 to 2.5, depending on the ratio of the radii, and certain other predictions of this result are said to be confirmed by experiments. P. S. Symonds, USA

1108. E. Reissner, "Finite deflections of sandwich plates," *J. aero. Sci.*, July 1948, vol. 15, pp. 435–440.

The author derives the equilibrium equations for the deflection of a sandwich plate consisting of a core and two face plates. The bending stress is considered constant over the face-plate thickness. Transverse shear stress deformation and transverse normal stress deformation are considered in the core. By suitable definition of resultant forces over the plate thickness a nonlinear system of equilibrium equations similar to those of von Kármán is obtained. The equations can be simplified by omitting the transverse normal stress terms, and utilized for the study of the deflection or buckling of rectangular plates. A buckling problem is treated. D. L. Holl, USA

1109. M. Zbigniew Krzywoblocki, "A general approximation method in the theory of plates of small deflection," *Quart. appl. Math.*, Apr. 1948, vol. 6, pp. 31–52.

In this paper a method is developed (from work done by S. Bergman) for the solution of the fourth-order partial differential equation satisfied by the transverse displacement w of a thin elastic plate. The method can be applied (whatever the boundary) in all cases in which the differential equation is homogeneous, but cannot necessarily be applied, for instance, to the bending of a plate by a transverse load when the equation is not homogeneous.

The displacement w is expressed as a double series of which the

typical term may be taken as the product of a power of $x + iy$ and of a function of $x - iy$; recurrence relations containing differential coefficients determine the function of $x - iy$ in the typical term from the functions in earlier terms of the series.

The method is illustrated by considering the elastic stability of a plate in the form of a right-angled triangle stressed so that there is a uniform thrust parallel to one of the sides containing the right angle. The equation for w is then homogeneous and has constant coefficients, the functions of $x - iy$ are elementary functions, and the earlier terms in the series for w can be determined simply. The boundary conditions that, for clamped edges, w and its normal derivative must both vanish are approximately satisfied by minimizing the line integral around the edge of the sum of the squares of w and its derivative. The numerical work required is heavy, and punch-card machines have been found convenient for it. W. R. Dean, England

1110. **S. Levy, A. E. McPherson, and F. C. Smith, "Reinforcement of a small circular hole in a plane sheet under tension,"** *J. appl. Mech.*, June 1948, vol. 15, pp. 160–168.

The first part of the paper compares the efficiencies of various types of reinforcements around a hole in a plane sheet subject to uniform tension in all directions. The radial displacements, the radial stresses, and the tangential stresses of three types of tapered reinforcements and three types of untapered (doubler plate) reinforcements are compared. A tapered reinforcement which concentrates most of its area at the edge of the hole is found to be the most efficient.

The second part presents a theoretical investigation of the effect of various proportions of doubler plate around a hole in a plane sheet which is under tension in one direction, upon the stress concentration, and radial displacement at the hole. This theoretical investigation was checked by eight tests involving various shapes of doubler plate reinforcements and various types of rivet arrangements. In one of the tests the doubler plate was on one side of the sheet only; this test was carried to destruction while the others were tested in the elastic range. The tests showed that the best agreement between theory and test was obtained when the doubler plates were attached with more than one row of rivets. Karl Arnstein, USA

Buckling Problems

(See also Revs. 1089, 1108, 1119)

1111. **W. Muckle, "Resistance to buckling of light-alloy plates,"** *Trans. N. E. Coast Instn. Engrs. Shipb.*, Apr. 1948, vol. 64, pp. 233–272.

This paper reports the results of a series of buckling tests on light-alloy plates. The alloys were of different temper and included aluminum alloys of 3 per cent magnesium, 5 per cent magnesium, and of the clad Duralumin type. The tests were somewhat similar to those previously conducted by J. Montgomerie on the buckling of steel plates. Two geometrically similar series of plates were tested, one set being half the size of the other. A range of span-thickness ratio of 34 to 80 was covered. In addition, some tests were made to study the effect of seams on the stability of plating.

Curves are drawn for the various alloys, showing the relation of buckling stress to span-thickness ratio. In addition, formulas for these relations are given and compared with Montgomerie's formula for steel. Considerable variation was observed in the buckling characteristics of the alloy materials depending on the temper. Elastic buckling is reported for the 5 per cent magnesium half-hard alloy, the 3 per cent magnesium of medium temper, and the clad Duralumin type. Inelastic buckling of soft plates takes place for low values of span-thickness ratio. A reduced modulus of elasticity was considered in the latter case, and the results of theory and experiments were compared.

In addition, formulas are developed for the ratio of the spacing of transverse stiffeners to the thickness of plating for the light alloys, in terms of this ratio for steel and the ratio of the working stresses for the two materials. Frank Baron, USA

1112. **F. J. Plantema, "Calculation of buckling loads of sandwich plates by means of the energy method (Berekening van de kniklast van sandwichplaten volgens de energiemethode I),"** *Nat. LuchtLab. Amsterdam Rap.*, no. S.332, Apr. 5, 1948, pp. 1–15.

The problem of determining the buckling load of flat sandwich plates with simply supported sides under biaxial compression is well known. The treatment of the problem with the aid of the energy method seems to be attractive when the loading conditions are more complex (for instance for shear). However, previous works cited [*Forest Prod. Lab. Reps.*, no. 1504 (1944), no. 1525 (1945), no. 1560 (1947)] are, according to the author, not entirely satisfactory from the standpoint of taking finite shearing rigidity into account.

The author sets out to make improvements on this point. In this Part I he computes, for purposes of comparison, the buckling load of plates under biaxial compression. The results are in good agreement with previous solutions. Numerical results are given for the case of an infinitely long plate under longitudinal compression. W. L. Esmeijer, Holland

1113. **K. B. Jackson and A. H. Hall, "Curved plates in compression,"** *Nat. Res. Counc. Can. Aero. Rep.*, no. 1, 1947, pp. 1–97.

End compression tests are described for two series of aluminum-alloy panels 18 in. long, 4 to 8 in. wide, and 0.018 to 0.036 in. thick, flat, and with radii of curvature of 24 or 48 in. The flat panels were held in slotted combs while the curved panels were bolted to comb elements simulating the restraint provided by a stringer.

The buckling loads were determined from curves of load as a function of average strain obtained with a load-strain recorder. The critical buckling load for 40 curved panels from the second series ranged from 50 to 90 per cent of Redshaw's theoretical value. Buckle contours after buckling were measured by using a series of vertical wires strung in front of the panel, illuminated by a line filament lamp to the left of the panel, the shadows on the panel being photographed.

The effective width after buckling was obtained as a function of the edge stress from the load-strain curves, and also from the shadow photographs. It was found that the ratio of effective width to initial width could be described by an empirical formula as the ratio of a reduced buckling stress to the edge stress, raised to a power which is a function of the edge stress. The formula is shown to be in agreement with previously reported experimental values for sheet stringer panels. Walter Ramberg, USA

1114. **H. Crate and Hsu Lo, "Effect of longitudinal stiffeners on the buckling load of long flat plates under shear,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1589, June 1948, pp. 1–46.

This is a report of theoretical and experimental studies which were made of the buckling, under shear loading, of long rectangular flat plates with several longitudinal stiffeners. The

panels considered are similar to plate-stringer combinations for wings of high-speed airplanes.

The theoretical treatment employs the energy method of elastic stability theory. The deflection patterns are represented by Fourier series. Strain energy due to twisting of the stiffeners is neglected, but strain energy due to bending of the stiffeners is taken into account. The analysis treats the case of an arbitrary number of stiffeners. Clamped edges and simply supported edges are investigated. The results of the analysis were found to be in fair agreement with the test data.

H. L. Langhaar, USA

1115. A. van Wijngaarden, "The elastic stability of flat sandwich plates" (in English), *Nat. LuchtLab. Amsterdam Rap.*, no. S-319, Feb. 1947, pp. 1–40.

The analytical investigation presented in this paper is concerned with the elastic stability of flat sandwich plates, having an isotropic core, under a combination of compressive and shear loads. The core is treated as a three-dimensional elastic body, thus opening the possibility of studying aeolotropic cores as well as "symmetrical" buckling of the face sheets.

From the equations of equilibrium and stability of the face sheets, a rather complicated expression for buckling stress is obtained for which approximate solutions are given for longitudinal compression only and for a simply supported plate. The buckle pattern corresponds to square waves, as in a simple plate, and for a core of zero thickness the buckling stress is $4\pi^2D/b^2$, the same as for a simple plate.

The approximate solution for shear alone is not so satisfactory. For the limiting case of zero core thickness, the critical buckling stress is found to be 27 per cent greater than that given by the exact solution for a simple plate. It is the author's intention to give this problem further consideration. Marshall Holt, USA

Joints and Joining Methods

1116. E. F. Nippes and W. F. Savage, "State of stress in arc welds made under transverse restraint," *Weld. Res. Suppl.*, July 1948, vol. 13, pp. 370–376.

The purpose of this investigation was to determine the state of stress which results from transverse restraint of the forces attending the violent heating and cooling cycles of the arc-welding process. The conditions of restraint imposed upon various geometries of groove-welded plates were selected to just avoid longitudinal cracking in first pass welds. The plate material used was ASTM A131-39 structural steel for ships, with yield and tensile strengths of 37,000 psi and 64,000 psi, respectively. The electrodes used were E6010, E6012, and E6020 at an average energy input of approximately 52,000 joules per inch.

Strains were measured by means of SR-4 electric resistance strain gages on, and one inch from, the center line of the welds. Strain measurements were taken after the plates had cooled to room temperature. Three types of stresses were determined: restraint, residual, and total. The difference in strain produced by the removal of the welded plate from the restraining fixture provided the "restraint" stress, the difference after subdividing the plate provided the "residual" stress, and the algebraic sum of the two was taken as the "total" stress.

Transverse stresses in the surface of first pass welds, produced at the threshold of cracking and made with a backing strip to avoid root notches, approached 65,000 psi, the ultimate strength of the deposited weld metal; the longitudinal stresses were approximately 40,000 psi, the yield strength of the deposited metal. Without a backing strip, even with careful attention to the avoidance of root notches, the transverse cracking limit stress on the surface of the weld was found to reach only 80 per cent of the ultimate strength of the deposited metal. Strains measured on the surface of completed multipass welds indicated that the transverse stress was reduced by multipass operation, while the longitudinal stress remained approximately the same as for first pass welds (that is the yield point stress).

Carl E. Hartbower, USA

Structures

(See also Revs. 1100, 1101, 1138)

1117. S. O. Asplund, "A study of three-dimensional pile-groups" (in English with summaries in French and German), *Publ. int. Ass. Bridge Struct. Engng.*, 1947, vol. 8, pp. 1–16.

A matrix treatment is presented for the analysis of three-dimensional pile groups. The piles are assumed to transmit only axial loads, and to act as simple columns, and the pier is assumed rigid. The introduction of fictitious piles for the case of irregular groups is also discussed. This leads to a solution by means of matrix iteration. Convergence proof for the general case is not included. Conrad C. Wan, USA

1118. D. McHenry and W. T. Walker, "Laboratory measurements of stress distribution in reinforcing steel," *J. Amer. Concr. Inst.*, June 1948, vol. 19, pp. 1041–1054.

Reinforced-concrete construction calculations are based on several assumptions (cracking of the concrete up to the neutral axis, relation between moduli of elasticity of steel and concrete, etc.) which had up to the present time very little experimental confirmation. The authors have made an important contribution by using SR-4 electric strain gages to measure the strains in the steel of reinforced concrete beams. Most of the values obtained are smaller (about 25 per cent) than those computed with the usual formulas, and the authors conclude that the concrete in the tension zone is doing more work than is assumed.

Although this conclusion seems to be qualitatively correct, it should be noted that if the crack in the concrete does not coincide with the position of a strain gage, the latter will not record the peak of strain. Even when it does coincide, since the width of the crack is small compared to the base length of the gage, this will record only an average, which will probably be smaller than the maximum actual strain. A. J. Durelli, USA

1119. F. E. Richart, J. O. Draffin, T. A. Olson, and R. H. Heitman, "The effect of eccentric loading, protective shells, slenderness ratios, and other variables in reinforced concrete columns," *Univ. Ill. engng. Exp. Sta. Bull.*, no. 368, Nov. 28, 1947, vol. 45, pp. 9–128.

The bulletin reports on a large number of tests on reinforced concrete columns made from 1916 to 1938. The tests concern three distinct questions: (1) The effect of combined bending and direct compression; (2) the effect of column slenderness on strength and the manner of failure; (3) the structural effect of the protective shells (fireproofing) of columns.

Although not previously published, the results of these tests were used in the preparation of the 1940 Joint Committee Report and of the ACI Building Code. Using the tests as a basis, the bulletin demonstrates the adequacy of current design practices. The tests on slender columns are also compared with the results of the tangent modulus and of the double modulus theories.

The bulletin contains a bibliography and extracts of results of significant European tests on the same questions.

Hans Bleich, USA

1120. **Birger Ludvigson, "Calculation of frames and arches by the method of primary moments (Beräkning av ramar och bågar enligt primärmomentmetoden),"** *Trans. Chalmers Univ. Technol. Sweden*, 1947, no. 57, pp. 1–112.

In the first chapter the author discusses several different methods for the calculation of frames composed of straight prismatic bars, principally the methods of Axel Efson and Hardy Cross. In the second chapter the methods are adapted and applied to systems of elastically clamped arches and curved bars. In connection with this chapter there are presented some tables of moment-functions which are applicable to the most common problems in this type of structural computation.

Ragnar Nilson, Sweden

Plastic Flow, Failure; Mechanics of Solid State

(See also Revs. 1093, 1097, 1107, 1129)

1121. **R. Hill, "A theory of the yielding and plastic flow of anisotropic metals,"** *Proc. roy. Soc. Lond. Ser. A*, May 27, 1948, vol. 193, pp. 281–297.

The yielding of an anisotropic metal is generally analyzed. The anisotropy considered is that resulting from preferred orientation of the crystal grains after the metal has been strained permanently in some simple manner.

The paper makes use of the concept of the plastic potential which was introduced by von Mises in 1928 for an isotropic ideally plastic solid. Von Mises showed that the plastic stress-strain relations in differential form

$$d\epsilon_y = d\lambda\left(\sigma_x - \frac{\sigma_y + \sigma_z}{2}\right), \quad \ldots d\gamma_{yz} = 3d\lambda\tau_{yz} \ldots\ldots [1]$$

($\sigma_x, \ldots\tau_{yz}, \ldots$ components of stress, $\epsilon_x, \ldots\gamma_{yz}, \ldots$ components of infinitesimal permanent strain, $d\lambda$ a positive, scalar factor of proportionality) may be derived by taking the partial derivatives with respect to the components of stress $\sigma_x, \ldots\tau_{yz}$ of the function

$$(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6(\tau_{yz}^2 + \tau_{zx}^2 + \tau_{xy}^2) = 4\sigma_o^2 \ldots\ldots [2]$$

where σ_o is the yield stress in tension. Thus

$$d\epsilon_x = d\lambda\frac{\partial f}{\partial\sigma_x}, \quad \ldots d\gamma_{yz} = 3d\lambda\frac{\partial f}{\partial\tau_{yz}} \ldots\ldots [3]$$

The author expresses the plastic potential for an anisotropic metal in a manner perfectly analogous to Equation [2] by letting

$$F(\sigma_y - \sigma_z)^2 + G(\sigma_z - \sigma_x)^2 + H(\sigma_x - \sigma_y)^2 + 2L\tau_{yz}^2 + 2M\tau_{zx}^2 + 2N\tau_{xy}^2 = 1 \ldots\ldots [4]$$

where $F, G, \ldots N$ are six constants characteristic of the state of anisotropy of a cold-worked metal. These constants are found to be dependent on the yield stresses X, Y, Z in the principal directions of anisotropy. By taking the partial derivatives of Equation [4] with respect to the components of stress, the incremental stress-strain relations may be derived for an anisotropic metal in the form

$$d\epsilon_x = d\lambda[H(\sigma_x - \sigma_y) + G(\sigma_x - \sigma_z)], \ldots d\gamma_{yz} = d\lambda L\tau_{yz} \ldots [5]$$

Several interesting applications of Equations [4] and [5] are made. By applying these equations to experiments by Koerber and Hoff (1928) on necking under uniaxial tension in thin flat bars of rolled steel sheet the author shows that necking in flat bars proceeds in two preferred orientations along two planes making certain angles with the axis (one of which has frequently been observed to be equal to 55 deg) and perpendicular to the wider sides of the bars. This is done by investigating the "plane strain problem of the flow" in an anisotropic metal, and afterward finding the planes in which the yield stress for simple shear becomes an extremum. The paper contains other examples and is one of the best papers written on recently developed extensions of the theory of flow to cases of anisotopic flow.

A. Nadai, USA

1122. **W. Prager, "Theory of plastic flow versus theory of plastic deformation,"** *J. appl. Phys.*, June 1948, vol. 19, pp. 540–543.

In the theory of plasticity it is customary to represent the stress-tensor as the sum of the stress deviation $\mathbf{S}$ and the spherical tensor $-p\mathbf{I}$, where $\mathbf{I}$ denotes the unit tensor and p the negative arithmetic mean of the three principal stresses. If the principal values of the stress deviation are denoted by s_1, s_2, and s_3, we have $s_1 + s_2 + s_3 = 0$.

It is well known that the so-called octahedral shearing stress, occurring in planes that have the same orientation with respect to the principal directions of stress as have the faces of an octahedron with respect to its axes, is represented by

$$\tau = [1/3\,(s_1^2 + s_2^2 + s_3^2)]^{1/2}$$

and is frequently used as the scalar measure of the intensity of stress.

If the change of the octahedral shearing stress is adopted as a criterion for "loading" ($\dot\tau > 0$) and "unloading" ($\dot\tau < 0$), then $\dot\tau = 0$ represents a "neutral" change of stress (which, for instance, occurs when the stress components are changed in such a manner that the principal stresses preserve their values while the principal directions rotate with respect to the material).

The author compares the theories of plastic deformation and of plastic flow, which are characterized by the two sets of equations

$$\left.\begin{aligned} 2G_o d\mathbf{E}''/dt &= g(\tau)d\mathbf{S}/dt + g'(\tau)\dot\tau\,S \text{ for } \dot\tau > 0 \\ 2G_o d\mathbf{E}''/dt &= 0 \qquad\qquad\qquad \text{for } \dot\tau < 0 \end{aligned}\right\} \ldots [1] \text{ (plastic deformation),}$$

$$\left.\begin{aligned} 2G_o d\mathbf{E}''/dt &= h(\tau)\dot\tau\,\mathbf{S} \quad \text{for } \dot\tau > 0 \\ 2G_o d\mathbf{E}''/dt &= 0 \qquad\qquad \text{for } \dot\tau < 0 \end{aligned}\right\} \ldots [2] \text{ (plastic flow),}$$

and states that it seems reasonable to demand that the stress-strain relations for both loading and unloading should predict the same change of strain when applied to a neutral change of stress. He concludes that this requirement is fulfilled by the theory of plastic flow, and is not fulfilled by the theory of plastic deformation, as can be seen from Equations [1] and [2] (in which obviously $\mathbf{E}''$ represents the plastic strain tensor) by putting $\dot\tau = 0$.

C. B. Biezeno, Holland

1123. **K. H. Swainger, "A new criterion of yielding in metals due to complex stresses,"** *Phil. Mag.*, Feb. 1948, vol. 39, pp. 122–133.

The author accepts the ellipse of yielding in the two-dimensional stress system as predicted by the energy-of-deformation theory. In the general case of anisotropy there is the possibility of the complete figure consisting of four quadrants of different ellipses. Any plane stress system, except two-dimensional hydrostatic tension or compression, is reduced to a simple shear

with a simple tension or compression at any point, by choosing suitable directions. The author proposes to apply experimental results obtained from a tension-shear experiment to this element to obtain each quadrant of the yield ellipse.

Similarly, any three-dimensional stress system, other than hydrostatic tension or compression, is reduced to simple tension or compression together with two shears. These define two ellipsoidal surfaces for the complete specification of yielding. If the metal is isotropic, two stress tests of tension-shear type give the yield criterion. Edward Saibel, USA

1124. F. Jonassen, W. P. Roop, and R. T. Bayless (editors), "Fracturing of metals (a seminar held at Chicago, October, 1947)," Amer. Soc. Metals, Cleveland, Ohio, 1948. Cloth, 9.2 × 6 in., 311 pp., 166 figs., $4.00.

This book comes nearer than any earlier attempt to bringing together contributions from the various schools of thought in the United States relating to the broad subject of the flow and fracture of metals. The meeting grew out of earlier conferences even more informal in nature and of which no record was kept. In the course of the seminar discussions, however, it became apparent that this was a unique occasion and that the discussions would be of interest to a wider audience. The participants consented to prepare written statements of their contributions and this volume is the result.

It would be difficult to cite in detail the material here published for the first time, although items of this nature are certainly included. In general, however, the contributors' ideas are presented in typical or in summary form rather than in the style of a monograph. At the same time the discussion is strictly technical and in no sense popular in nature. It starts from the physical-metallurgical point of view of Zener, Hollomon, Macklin, and Nabarro, proceeds with the phenomenological theories of Dorn, Saibel, and Poncelet, and spreads out into the experimental studies of Sachs, Lubahn, Shearin and associates, Read and associates, and Bridgman. Other contributions by Slater, Parker, Roop, Marin, and Donnell are included. The emphasis is on fracture rather than flow, and plasticity, either in its theoretical or practical aspects, is not considered.

Typical of the most useful material is the comprehensive review and evaluation, with 38 references, of the notched round tensile bar as a means of study of the properties of samples of metal, by Lubahn. But the greatest value of the volume lies in placing with such a summary other different but related and pertinent treatments of the subject. Some continuity of thought is shown in the repeated references to Griffith's microcrack theory.

The single papers will doubtless be listed separately in more detailed bibliographic references. A summary of the seminar is included, more as informal comment on selected details which indicate the general nature of the work of the different contributors than as a guide in standard bibliographic form. The title accurately describes the contents. W. P. Roop, USA

1125. M. B. Millenson and S. S. Manson, "Determination of stresses in gas-turbine disks subjected to plastic flow and creep," *Nat. adv. Comm. Aero. tech. Note*, no. 1636, June 1948, pp. 1–45.

This article presents a very interesting procedure for using the finite-difference method to evaluate the effects of plastic deformation upon the stress distribution in disks rotating at high speeds. The effect of various temperature gradients is included for the starting, steady operation, and stopping conditions.

The paper demonstrates the power of these procedures to meet almost any set of assumed conditions. The authors claim that the method permits nontechnical personnel to make the calculations with a minimum of engineering supervision. However, they claim only qualitative indications, and come to the obvious conclusion that if the amount of creep is small, the effect on stress distribution is also small. R. G. Sturm, USA

1126. B. W. Sakmann and B. G. Rightmire, "An investigation of fretting corrosion under several conditions of oxidation," *Nat. adv. Comm. Aero. tech. Note*, no. 1492, June 1948, pp. 1–57.

The fretting corrosion occurring at the contact areas of a small metal sphere and the flat top of a metal cylinder was visually observed and photographically recorded. Electromagnetically produced vibration was transmitted to the cylindrical specimen through a flexible steel pillar fastened to the top of the vibrating member. Static load was applied on the spherical specimen bearing on the cylindrical specimen.

Steel, phosphor-bronze, tin, aluminum, aluminum alloy, lead, lead-plated steel, and chromium steel were tested under identical conditions of load and slip, in air, vacuum, oxygen, and helium, respectively.

The test results show that chemical action is of primary importance, and that hard oxide formation does not give protection to metals, but rather increases the rate of wear, the worn-off debris serving as an abrasive. If one of the metals is soft, the hard oxide fragments may become embedded in the softer metal, thus reducing the rate of wear. Hans F. Winterkorn, USA

1127. E. J. Wiggins, "Power production from nuclear reactors," *Engng. J. Montreal*, June 1947, vol. 30, pp. 268–275.

The author discusses the production of power from primary as well as from secondary piles. Schematic arrangements of several types of hypothetical nuclear power plants are outlined. The most promising immediate applications of nuclear energy and of radiation are discussed, and the effects of radiation on structural materials and on personnel are listed.

Newman A. Hall, USA

1128. K. H. Swainger, "Strain energy in greatly deformed elastic or inelastic anisotropic engineering metals," *J. Franklin Inst.*, June 1948, vol. 245, pp. 501–516.

This paper is mainly a summary of the author's previous publications, and so is based upon his very unusual ideas about stress-strain and strain-displacement relations. The additional result obtained is an expression in terms of stress and strain for the work done per unit volume during an elastic or plastic deformation.

D. C. Drucker, USA

Design Factors, Meaning of Material Tests

(See also Rev. 1093)

1129. R. C. Stout and L. J. McGeady, "The meaning and measurement of transition temperature," *Weld. Res. Suppl.*, June 1948, vol. 13, pp. 299–302.

The investigators have attempted to evaluate the various tests which are employed at present to determine the brittleness of steel resulting from "transition temperature" phenomena. They classify the various methods of testing into two broad divisions: (1) Those such as bend angle at maximum load, contraction of area and elongation, which probably measure the ductility of steel before cracking becomes extensive; and (2) those such as fracture appearance, nominal strength, and energy after maximum load measurements which reflect the behavior of the steel

during propagation of the crack across a section. It is concluded that, in general, the first type of test is more sensitive to the geometrical shape of the specimen than the second. Moreover, the first type of test appears to give a lower value of the transition temperature than the second.

The authors do not yet feel in a position to recommend the type of test to be used in a given case but feel that the subject merits careful thought, since the different methods of test require different interpretation. They suggest that the ultimate use to which the steel will be put may determine the type of test to be employed. For example, a test designed to measure the ability of the steel to resist the growth of a crack (type 2) is probably more important for ship plate than a test of type 1. Conversely a test of type 1 may be of more interest for a steel to be used in a pressure vessel in which minor flow is of interest.

Frederick Seitz, USA

Material Test Techniques

(See also Revs. 1081, 1113, 1126, 1129, 1134)

1130. P. W. Bridgman, "The compression of 39 substances to 100,000 KG/CM^2," *Proc. Amer. Acad. Arts Sci.*, Mar. 1948, vol. 76, pp. 55–70.

This paper presents results of a study of pressure-volume relationships for substances (including elements, sulphides, selenides, tellurides, and six glasses) under extreme pressure, and is a continuation of a program of measurement previously initiated by the author [*Proc. Amer. Acad. Arts Sci.*, 1942, vol. 74, pp. 425–440; 1945, vol. 76, pp. 1–7]. A number of changes made in the apparatus to improve the performance and accuracy of measurement are described in detail. T. J. Dolan, USA

1131. C. Sălceanu, "New method for measuring the viscosity of metals (Nouvelle méthode pour la mesure de la viscosité des métaux)," *C. R. Acad. Sci. Paris*, May 31, 1948, vol. 226, pp. 1798–1800.

Values of damping coefficients of various materials were obtained by observing torsional vibrations of thin wires of diameter d. The frequency and the time to reduce the amplitude of vibration to half its original value were measured. The damping is expressed in terms of the coefficient of viscosity η, and the following values were obtained:

Material	d(cm)	$\eta/10^8$
Aluminum	0.05	6.1
Iron	0.03	21.2
Steel	0.03	21.9
Lead	0.0275	25.7
Silver	0.0255	50.6
Nickel	0.025	64.0
Copper	0.0235	106.0
Platinum	0.0165	111.3
Tungsten	0.019	481.0

Larger values were obtained when the wire was heated by a flow of current. It is pointed out that these values are much larger than those obtained by other investigators except for iron, aluminum, and lead. (Reviewer's note: The "viscosity" is defined as $G/(2\pi f_o Q)$ where G is the shear modulus, f_o the resonant frequency, and Q the ratio of the system energy to the dissipated energy.) Robert Fehr, USA

1132. J. H. Toulouse and P. J. Barcus, "Load concentration in corrugated paper," *Amer. Soc. Test. Mat. Bull.*, no. 152, May 1948, pp. 77–79.

A method of testing interior corrugated paper packing for bottles is developed. Concentration of load at contact point of bottle and paper plotted versus conbur foot falls yields a hyperbolic curve. Single-wall corrugated board and double-thickness board give different results, which indicates a choice of wall to be made on the basis of a minimum average inclined impact test value. E. A. Brittenham, Jr., USA

1133. W. J. Lyons and I. B. Prettyman, "Method for the absolute measurement of dynamic properties of linear structures at sonic frequencies," *J. appl. Phys.*, May 1948, vol. 19, pp. 473–480.

An apparatus employing electromagnetic oscillation for the determination of the dynamic stretch modulus, the coefficient of internal friction, and the hysteretic energy loss of textile yarns and cords at longitudinal resonant frequencies of vibration up to 300 cps is described. Experiments indicate that the energy absorption by the instrument is negligible, leading to reliable measurement of these properties.

Specific values of dynamic modulus and internal friction are given under controlled conditions of temperature and humidity, for resonant frequencies ranging from 75 to 300 cps. These tests show a hyperbolic relationship between the internal friction and the resonant frequency. Other tests made show an increase in dynamic modulus as the mean cord tension is increased.

Louis F. Coffin, Jr., USA

Mechanical Properties of Specific Materials

(See also Revs. 1081, 1118, 1130, 1131, 1133)

1134. J. J. Lamb and B. M. Axilrod, "Tensile stress-strain relationships of laminated plastics for small strains," *Amer. Soc. Test. Mat. Bull.*, no. 151, Mar. 1948, pp. 59–69.

This investigation was made to obtain more precisely the tensile stress-strain characteristics of typical laminates for small strains, to determine empirical equations to fit the data, and to consider the suitability of terms employed to describe the tensile stress-strain properties of laminated plastics. The authors' conclusions are as follows:

1 An empirical parabolic expression fits the tensile stress-strain curves of representative plastic laminates at small strains better than a linear expression.

2 The initial tensile modulus of elasticity obtained by fitting a least-squares straight line to the stress-strain data for the first 0.1 per cent strain was 2 to 8 per cent less than the corresponding value obtained by fitting a least-squares parabola.

3 Offset stress values for strain offsets of 0.001 to 0.01 per cent are sensitive to test procedure and method of analyzing the data, and are not practical to obtain in routine testing of plastic laminates.

4 The use of proportional limit is to be avoided because its determination is affected by the same variables as offset stress for small offset, and for such laminates the stress-strain diagram is not linear.

5 The reporting of secant moduli of elasticity is recommended for routine testing of plastic laminates.

Maxwell Gensamer, USA

1135. R. F. Geller, "Ceramic bodies for turbojet blades," *Soc. auto. Engrs. J.*, June 1948, vol. 56, pp. 46, 48–49 (full paper in preprint form, 10 pp.).

This paper presents data acquired at the National Bureau of Standards on the physical properties of ceramic materials developed at that agency for use under stress at elevated tempera-

tures. These data are particularly important because the ceramic bodies discussed were early found to be far superior to any commercial refractories.

Tensile strengths over 15,000 psi at 1800 F and over 10,000 psi at 1900 F were measured. For applications where stress is proportional to density, as for turbine blades under centrifugal force, the strength-weight ratios of the ceramic materials are superior to those of the best high-temperature alloys for temperatures above 1500 F. Maximum creep rates were found to be 0.0002 to 0.0008 per cent per hour at 1800 F and 16,000 psi, and 0.0003 to 0.0004 per cent per hour at 1900 F and 10,000 psi.

Thermal conductivity and thermal expansion were found to be poorer for these ceramic bodies than for metals. Thermal and mechanical shock resistance may not be adequate for turbine-blade usage. A. R. Bobrowsky, USA

1136. J. K. Galt, "Mechanical properties of NaCl, KBr, KCl," *Phys. Rev.*, June 15, 1948, vol. 73, pp. 1460–1462.

The elastic constants of single crystals of NaCl, KBr, and KCl were measured at 10 mc per sec using the pulsed ultrasonic method described by Huntington [*Phys. Rev.*, 1947, vol. 72, p. 321]. The ratios of the strain-optical constants were determined by the method of Mueller [*Z. Krystallogr.*, 1938, vol. A99, p. 122]. The results are in good agreement with those of other investigators. The elastic-constant measurements on KBr were extended to low temperatures. Martin Greenspan, USA

1137. C. B. Norris and G. E. Mackin, "An investigation of mechanical properties of honeycomb structures made of resin-impregnated paper," *Nat. adv. Comm. Aero. tech. Note*, no. 1529, May 1948, pp. 1–39.

Tests are described of the mechanical properties of honeycomb structures made from various resin-impregnated corrugated papers and suitable for use as sandwich cores. Shear strengths and moduli of rigidity compared favorably with those of balsa wood. Normal stress properties were lower than for balsa wood but considerably higher than for certain other core materials of similar density. The optimum content of impregnating resin was about 50 per cent. John E. Goldberg, USA

Soil Mechanics; Seepage

1138. Robert D. Chellis, "The relationship between pile formulas and load tests," *Proc. Amer. Soc. civ. Engrs.*, May 1948, vol. 74, pp. 635–654.

The bearing capacity of piles is in practice determined by three methods: dynamic formulas, static formulas, and load tests. Because of their easy use, dynamic formulas are much employed. Their number is great but although most of them are based on mechanical considerations, the results obtained differ very much. Numerous attempts have been made to verify these formulas by load tests, and in the present article the author compares the results obtained for 45 piles, tested by direct loading, to the values calculated by the following formulas: The Engineering News (modified), the Eitelwein (modified), the Navy-McKay and the Pacific Coast Uniform Building Code used in the USA, the Canada National Building Code used in Canada, and the Hiley formula used in England.

This examination shows that the Hiley, the Pacific Coast, and the Canadian National formulas give values which group well with the direct-load tests, while the other formulas give values differing very much from the direct-load tests. If the latter formulas are employed, the author recommends checking their results with those given by the Hiley or by static formulas, or better by direct-load tests. Aurel A. Beles, Roumania

1139. J. Florentin and G. L'Heriteau, "Remarks on some highly preconsolidated clays (Remarques sur quelques marnes fortement préconsolidées)," *Géotechnique Lond.*, June 1948, vol. 1, pp. 59–65.

The authors consider consolidation characteristics of preconsolidated inorganic clay deposits existing below the free ground water level. Data are presented to show that such clays may contain appreciable quantities of free gas which materially affects their time rate of volume adjustment due to loading changes. The authors postulate how this gas could originate and show how, by virtue of the Jamin effect, certain pecularities in the behavior of such clay deposits can be explained.

The authors theorize that, when a soil containing free gas is loaded, some of the gas existing in the form of bubbles goes into solution in the pore water because of the increase in gas pressure at the gaseous-liquid interface. During the consolidation process, as the pressure in the fluid phase of the soil system decreases, the gas returns to bubbles. Thus, at the beginning of the consolidation process the rate of volume adjustment is accelerated while at the end the rate is retarded. The authors suggest certain modifications in testing procedures and in the interpretation of test results. R. E. Fadum, USA

Potential or Laminar Incompressible Flow

(See also Revs. 1092, 1144)

1140. L. G. Loitsiansky, "Drag of a grid of profiles in a flow of a viscous incompressible fluid" (in Russian), *Appl. Math. Mech. (Prikl. Mat. Mekh.)*, July-Aug. 1947, vol. 11, pp. 449–458.

The author first sets up exact expressions for the reactions on a cascade in a viscous incompressible fluid in terms of the total head loss, the circulation, and the "free-stream" velocities. Then the assumption is made that at the downstream station, where the boundary layers from adjacent profiles merge, the velocity is nearly uniform, that is, that the square of the differences between velocities at any two points at this station can be neglected. This makes it possible to express the total head loss and the reaction normal to the cascade axis in terms of the boundary-layer momentum thickness at this station. Plausible arguments, partly based on a formula by Squire and Young, relate the momentum thickness at this station to the momentum thickness at the trailing edge of any profile. Thus in case the pressure distribution over a profile is known, the momentum thickness at the trailing edge, and hence an estimate for the cascade reactions, can be obtained. M. V. Morkovin, USA

1141. Carl Kaplan, "On a new method for calculating the potential flow past a body of revolution," *Nat. adv. Comm. Aero. Rep.*, no. 752, 1943 (issued in 1948), pp. 1–13.

In an earlier paper [*Nat. adv. Comm. Aero. Rep.*, no. 516, 1935] the author studied axial and transverse flow about a body of revolution in terms of elliptic-cylindrical co-ordinates. This method of approach is particularly adaptable to ellipsoids and hyperboloids of revolution, although the analysis can be applied to other shapes. The present report introduces a new system of orthogonal co-ordinates, one of the co-ordinate lines being the transformed meridian profile. As a result, a process of iteration is established for the determination of the velocity potential of an arbitrary body of revolution by means of simple quadratures.

Following the development of the general theory, applications of the method are given for two types of meridian sections. In the first case a symmetrical Joukowski profile with rounded nose and tail is considered, and the resultant pressure distribution calculated. Agreement with previously determined results is shown to be excellent. The second example treats a meridian profile corresponding to an NACA low-drag symmetrical airfoil-shape with abscissas and ordinates given numerically. Comparison between the pressure distribution for the body of revolution and the two-dimensional profile is given. Max A. Heaslet, USA

Turbulence, Boundary Layer, etc.

(See also Rev. 1156)

1142. P. Casal, "On a vector field of zero divergence subject to a homogeneous probability distribution. Application to homogeneous turbulence (Statistique d'un champ homogène de vecteurs aléatoires de divergence nulle. Application à la turbulence homogène)," *C. R. Acad. Sci. Paris*, Mar. 15, 1948, vol. 226, pp. 870–872.

Let $\bar{a}$ be a vector (components a_1, a_2, a_3) assigned to the point $\bar{x}$ (co-ordinates x_1, x_2, x_3), and div $\bar{a} = 0$. If $\bar{a}$ is subject to a probability distribution $P(\bar{a}; x)$ such that the expectation of a product $a_i(\bar{x})a_j(\bar{x}')$—that is, an element of the correlation tensor—depends on the difference $y = x - x'$ only

$$E\{a_i(\bar{x})a_j(\bar{x}')\} = A_{ij}(y),$$

we say that the distribution field is homogeneous. The author proves that if the field of a is homogeneous, the same is true for $b = \text{curl } a$, and

$$B_{ij} = E\{b_i(x)b_j(x')\} = \Delta A_{ij} + \frac{\partial^2 U}{\partial y_i \partial y_j} - \delta_{ij}\Delta U$$

where $U = A_{11} + A_{22} + A_{33}$, δ_{ij} as usual. Since div curl $= 0$, the field of $\bar{c} = \text{curl } b$ is again homogeneous, and it turns out that $C_{ij} = \Delta\Delta A_{ij}$. This formula can be reversed by using a Poisson integral twice. In the application to turbulence the velocity vector $\bar{u}$ is identified with b and, in this way, a relation is found between the correlation tensors of $\bar{u}$ and of curl $\bar{u}$.

R. von Mises, USA

1143. A. Ulrich, "Theoretical investigation of drag reduction in maintaining the laminar boundary layer by suction," *Nat. adv. Comm. Aero. tech. Memo.*, no. 1121, June 1947, pp. 1–30 (transl. from *Aero. Inst. T. H. Braunschweig Ber.*, no. 44/8, Mar. 20, 1944).

Stability calculations of the Tollmien-Schlichting type are performed on three groups of calculated velocity profiles of laminar boundary layers on flat plates for (1) a longitudinal flow with uniform continuous suction, (2) a longitudinal flow with continuous suction, normal wall velocity inversely proportional to square roof of distance from leading edge, (3) a jet impinging normally with uniform continuous suction.

The effect of suction is to increase the stability of the laminar boundary layer, to increase the critical Reynolds number, and to decrease the friction drag coefficient. The effect of negative suction is to decrease both stability and critical Reynolds number. The uniform suction is found to be superior to the variable suction for longitudinal flow with chord Reynolds number between 10^6 and 10^8. In this range of Reynolds number the minimum suction quantity per side of plate for maintenance of the laminar boundary layer varies from $1.1 \times 10^{-4} A U_o$ to $2.8 \times 10^{-4} A U_o$ for the longitudinal flow with variable suction, and is constant at $1.18 \times 10^{-4} A U_o$ for the longitudinal flow with uniform suction, where A is the plate surface area and U_o the free-stream velocity.

W. G. Cornell, USA

1144. D. Meksyn, "The laminar boundary-layer equations," *Proc. roy. Soc. Lond. Ser. A*, Mar. 18, 1948, vol. 192, pp. 545–575.

The author considers the flow around a boundary of not very large curvatures, the potential flow around which is known. The laminar motion can be expressed in the space of α (the velocity potential) and β (the stream function) by a function ψ of α and β, whose second derivative with respect to β is a slowly varying factor multiplied by an exponential function, rapidly tending toward zero with β. Introducing the variables

$$\sigma = \tfrac{1}{2}[2u_o'/(\nu\gamma)]^{1/2}\beta, \ \psi = (2\nu u_o\gamma)^{1/2} f(\sigma, \gamma), \ \gamma = l + \alpha$$

(l is a length such that $\gamma = 0$ at the stagnation point), he gets for the function $f(\sigma,\gamma)$ at the boundary $\sigma = \beta = 0$ the equation $f''' + ff'' = \lambda(l - f'^2)$. This is the well-known equation of Falkner and Skan (1930) with a different meaning for λ. This equation is integrated numerically by the method of Hartree (1937) for a circular and an elliptic cylinder.

The results of the computations seem to be in fairly good agreement with the experimental results of Fage and Falkner (1931) and Schubauer (1935). J. Kampé de Fériet, France

Compressible Flow, Gas Dynamics

(See also Rev. 1160)

1145. Y. Kuo, "Two-dimensional irrotational transonic flows of a compressible fluid," *Nat. adv. Comm. Aero. tech. Note*, no. 1445, June 1948, pp. 1–91.

This report is a modification and extension of the work of Tsien and the present author [*Nat. adv. Comm. Aero. tech. Note*, no. 995] to cover flows with small circulation by the hodograph methods, in the subsonic and transonic speed ranges. In the hodograph plane the stream function and velocity potential are expressed as infinite series of trigonometric functions of ϑ and of hypergeometric functions of q, where ϑ is the azimuth of the velocity vector and q its magnitude. The difficulty involved in this method is to find the coefficients of these infinite series so that the flow in the hodograph plane corresponds to the desired flow in the physical plane. This is partially achieved by constructing a compressible flow in the hodograph plane which for a zero Mach number reduces to a known incompressible flow about a similar body. Paul A. Libby, USA

1146. S. A. Hristyanovich and I. M. Yuryev, "Subsonic gas flow past a wing profile" (in Russian), *Appl. Math. Mech. (Prikl. Mat. Mekh.)*, Jan.-Feb. 1947, vol. 11, pp. 105–118.

This paper was presented at the International Congress for Applied Mechanics, Paris, France, 1946.

Using the hodograph method, the authors describe a procedure for the determination of circulatory flow patterns around a profile, under a simplified assumption about the pressure-density relation. The equations for the potential and stream functions, φ and ψ, assume the form $\varphi_\mu = K^{1/2}\psi_\nu$, $\varphi_\nu = -K^{1/2}\psi_\mu$, $K = (1 - M^2)/\rho^2$ where μ is a function of the speed, ν the angle which the velocity makes with the positive x-axis, M is the Mach number, and ρ the density. The authors approximate K by its value K_∞ at infinity. The equations for φ and $\hat{\psi} = K^{1/2}{}_\infty \psi$ become the Cauchy-Riemann equations, $\varphi + i\hat{\psi} = f$ can be regarded as the complex potential of a flow of an incompressible fluid.

Using this idea, the authors give a parametric representation for the flow pattern in the physical plane in terms of an arbitrary analytic function f, of a complex variable. They obtain the conditions for the circulation in order that the given hodograph represent a flow around a closed curve in the physical plane. These conditions are closely related to those obtained by the reviewer [*Nat. adv. Comm. Aero. tech. Note*, no. 972, 1945, secs. 13, 14, and *Trans. Amer. math. Soc.*, 1947, vol. 62, p. 484]. A number of cases, as a flow around a domain bounded by two circular arcs and profiles with sharp corners, are discussed.

It is shown that for an incompressible flow about a body whose contour contains no corners, the corresponding body in the compressible flow will have corners on its contour, and vice versa. The closure condition gives the Prandtl-Glauert correction for the circulation in compressible flow. An attempt is also made to show that the Joukovsky lift theorem holds for subsonic compressible flow, and a moment formula is derived.

The reviewer wishes to point out that essentially the same formulas for parametric representation of flow in the physical plane by means of an analytic function of a complex variable have also independently been obtained by both A. Gelbart, ["On subsonic compressible flows by a method of correspondence," *Nat. adv. Comm. Aero. tech. Note*, no. 1170, 1947] and C. C. Lin, ["On an extension of the von Kármán-Tsien method to two-dimensional subsonic flows with circulation about closed profiles," *Quart. appl. Math.*, Oct. 1946, vol. 4].

Stefan Bergman, USA

1147. M. Schaefer, "Remarks on the work: 'Two boundary value problems in the theory of hyperbolic partial differential equations of the second order with applications to supersonic gas flows,' by F. Frankl and R. Aleksyiva," *Hdqtrs. Air Mat. Comm. Dayton Transl.*, no. A9-T-4, 1948, pp. 1–6 (transl. from *T. H. Dresden Peenemunde Arch.*, no. 44/2a, June 1, 1944).

This is an inflated presentation of the trivial fact that the system of the equations of characteristics is singular along the limiting line, at every sonic point, and also where a Mach line meets at right angles one of the Cartesian axes in the physical plane.

A. W. Wundheiler, USA

1148. J. Conrad Crown, "Supersonic nozzle design," *Nat. adv. Comm. Aero. tech. Note*, no. 1651, June 1948, pp. 1–34.

A review is given of various methods for the design of two-dimensional, supersonic nozzles. Virtually all these methods stem from the stepwise graphical procedure of Prandtl and Busemann, except for Foelsch's closed analytic solution for nozzle contours under special initial conditions. A modification of the "supersonic protractor" invented by Temple for graphical application of the method of characteristics is described.

Ascher H. Shapiro, USA

1149. P. Carrière, "Computation of the velocity field in a supersonic cylindrical nozzle from the photographs of Mach lines, and the correction method for tracing the nozzle (Calcul du champ de vitesses dans une tuyère supersonique cylindrique à partir des photographies de lignes de Mach, et méthode de correction du tracé de la tuyère)," *C. R. Acad. Sci. Paris*, June 7, 1948, vol. 226, pp. 1884–1886.

The author gives a procedure for correcting the velocity field that can be obtained by an optical method (in this case the schlieren method, which the author calls Foucault's method). The principle used for obtaining the velocity field is to measure the Mach angles at points of intersection of Mach waves. In practice results obtained in this manner are quite scattered, due to errors of measurements. The author's procedure leads to a coherent velocity field, and is based on the Prandtl-Busemann theory of one-dimensional supersonic flow. The procedure by which the nozzle profile is corrected is also given.

Ahmed D. Kafadar, USA

1150. Carl Kaplan, "The flow of a compressible fluid past a curved surface," *Nat. adv. Comm. Aero. Rep.*, no. 768, 1943 (issued in 1948), pp. 1–23.

One of the most expedient processes whereby the fundamental differential equation for the velocity potential of a two-dimensional compressible flow field may be solved employs iteration methods together with the assumption that the velocity potential is expressible as a power series in some basic parameter. For the present paper the author chooses as his basic parameter the thickness coefficient of the body, and in this manner is able to obtain solutions for fields involving both subsonic and supersonic regimes of flow.

Following the derivation of the basic equations, application is made to the case of a symmetrical shape cusped at both leading and trailing edge, in order to avoid stagnation points in the flow. Numerical calculations are carried out for a section with thickness equal to $^1/_5$ of the chord length for free-stream Mach numbers up to $M = 0.83$. At this point the series solution apparently becomes divergent and leads to the concept of a limiting Mach number. The inference is made that this limiting Mach number may furnish a more accurate estimate as to the Mach number at which the compressibility shock makes its appearance.

When the upper half of the body is considered, the solution is applicable to the effect of bumps on the surface of a two-dimensional configuration, and thus yields an approximation of pressure distributions involving local supersonic regions on an airfoil section.

Max A. Heaslet, USA

1151. D. C. Pack, "On the formation of shock waves in supersonic gas jets," *Quart. J. Mech. appl. Math.*, Mar. 1948, vol. 1, pp. 1–17.

Two examples of a two-dimensional supersonic jet are examined by means of the characteristics method. Special attention is given to the formation of shocks. The results are used to explain the flow at the muzzle of a gun.

Gottfried Guderley, USA

1152. L. A. Galin, "A plane rectangular wing in a supersonic flow" (in Russian), *Appl. Math. Mech. (Prikl. Mat. Mekh.)*, July-Aug. 1947, vol. 11, pp. 465–474.

In Part I, the author uses repeated integrals of "basic solutions" of the linearized supersonic flow equations to build up a simple integral representation for the velocity potential and its derivatives on the surface of a rectangular wing of finite aspect ratio. Thus the lift on such a wing of arbitrary camber reduces to a single integration of a linear multiple of the camber function. The solutions for rectangular wing with camber and twist are also indicated. The "basic solution," similar to Green's function, is A. Busemann's potential [*Dtsch. Akad. Luftfahrtforsch. Schr.*, 1943, no. 3] for a flat rectangular plate with induced vertical unit velocity over the plate.

Part II requires papers by N. Kochin [*Appl. Math. Mech. (Prikl. Mat. Mekh.)*, 1942, vol. 6] and E. Krasilshchikova [*Appl. Math. Mech. (Prikl. Mat. Mekh.)*, 1947, vol. 11, no. 1 (see Rev. 1034, Applied Mechanics Reviews, June 1948)] as background, and deals with forces on a rectangular, harmonically oscillating wing in linearized supersonic flow. The solution of the governing telegraph equation is reduced to the solution of

the type of problem treated in Part I. The solution for a wing bending in the direction of the flow is given in terms of an infinite series which is doubtless very difficult to sum.

A short English description of the fundamental equations concludes the paper. There are a number of misprints.

M. V. Morkovin, USA

1153. F. I. Frankl, "Uniqueness of solution of the problem of supersonic flow past a wedge," *Hdqtrs. Air Mat. Comm. Dayton Transl.*, no. A9-T-20, 1948, pp. 1–9 [transl. from *Appl. Math. Mech. (Prikl. Mat. Mekh.)* vol. 10, no. 3, 1946.]

It is well known that supersonic flow past a wedge may be of three types. For the first type, in which the free-stream velocity only slightly exceeds the velocity of sound, the shock wave is detached from the vertex of the wedge, and there is a local domain of subsonic velocities between the wave front and the wedge. The second type corresponds to a range of free-stream velocities such that the shock wave originates at the vertex of the wedge while the velocity of the flow between the wave and the edge remains subsonic. In the third type, the velocity of the flow between the shock wave and the wedge is constant and supersonic.

Let θ_0 be half the angle of the wedge, or the angle between the edge of the wedge and the free-stream direction. Through the origin in the hodograph plane we draw a straight line l at an angle θ_0 with respect to the u-axis, u being the horizontal component of the velocity. If the line l does not intersect the Busemann shock polar the flow is of type one. If it does, and both points of intersection correspond to subsonic velocities, the flow is of the second type; otherwise it is of the third.

For the second and third types the velocity vector behind the wave front is determined uniquely by θ_0; its direction by l and its magnitude by one of the points of intersection of l with the shock polar. Experiment indicates that the point to be chosen is the one farther from the origin; this has not yet been determined theoretically except by the heuristic argument set forth by Frankl [*Bull. Acad. Sci. USSR Ser. Math. (Izv. Akad. Nauk SSSR Ser. Mat.)*, Mar. 9, 1945]. In the present paper the author shows how to reduce the problem of a flow past a wedge to a boundary value problem in a given domain of the hodograph plane and proves that its solution is unique. Abe Gelbart, USA

Aerodynamics of Flight; Wind Resistance

(See also Revs. 1095, 1141, 1143, 1150, 1160, 1162, 1164)

1154. Robert T. Jones, "A method for studying the hunting oscillations of an airplane with a simple type of automatic control," *Nat. adv. Comm. Aero. Rep.*, no. 801, 1944 (issued in 1948), pp. 1–4.

The differential equations governing the yawing or pitching motion of an airplane are written in a form involving the time operator, D. It is assumed that the control mechanism is linear, and the analysis of the steady-state response of the system to disturbing functions of the "unit" and "square-wave" type is carried out by the use of the symbolic D operator. The report concludes with a short discussion of the effects of time lag due to backlash in the control mechanism.

This report was written in 1944. Since that time much work has been done in the analysis and synthesis of servomechanisms and closed-cycle control systems. The theory presented in this report represents a pioneer effort in this field.

Louis A. Pipes, USA

1155. W. Gracey, "The experimental determination of the moments of inertia of airplanes by a simplified compound-pendulum method," *Nat. adv. Comm. Aero. tech. Note*, no. 1629, June 1948, pp. 1–26.

An airplane is swung as a gravity pendulum about an axis parallel to the known direction of the longitudinal or spanwise axis, and the period of oscillation is measured. The length of suspension is then changed. Elementary formulas determine the vertical location of the center of gravity and the corresponding central moments of inertia. The influence of the air resistance and a means of correction is discussed.

John E. Goldberg, USA

1156. E. A. Horton and J. H. Quinn, Jr., "Analysis of the effects of boundary-layer control on the take-off performance characteristics of a liaison-type airplane," *Nat. adv. Comm. Aero. tech. Note*, no. 1597, June 1948, pp. 1–61.

A performance analysis is made to determine whether or not boundary-layer control by suction could reduce the minimum take-off distance of a four- or five-place liaison-type airplane below that obtainable with conventional high-lift devices. It is found that considering the added equipment for boundary-layer control, the absolute minimum total take-off distance (over a 50-ft obstacle) will not be reduced unless the aspect ratio is ten or more. However, for a given maximum speed, the ground run is decreased and the stalling speed is reduced by 20 to 25 per cent for all cases by use of the equipment.

Because of induced-drag effects, there is an optimum (not necessarily the highest possible) maximum lift coefficient for take-off distance, which is a function of wing loading, aspect ratio, etc. It is also shown that the optimum horsepower loading for minimum take-off distance is about 8.5 to 9.0 lb per hp for the conventional and boundary-layer control airplanes respectively.

E. Arthur Bonney, USA

1157. A. I. Neihouse, "The effect of variations in moments of inertia on spin and recovery characteristics of a single-engine low-wing monoplane with various tail arrangements, including a twin tail," *Nat. adv. Comm. Aero. tech. Note*, no. 1575, May 1948, pp. 1–45.

In an investigation made in the Langley 15-ft free-spinning tunnel eight different wing arrangements and four different tail arrangements, including a twin tail, were tested. The moments of inertia about the three airplane axes were changed by a constant percentage, and the results compared with each other and with those previously presented for variation of the airplane's relative density. Martin Goland, USA

1158. W. H. Phillips, "Effect of steady rolling on longitudinal and directional stability," *Nat. adv. Comm. Aero. tech. Note*, no. 1627, June 1948, pp. 1–36.

The stability of the motion of an aircraft flying with a steady rolling velocity is analyzed by means of Euler's equations. It is assumed that the airplane in nonrolling flight has a single degree of freedom in pitch and in yaw, and that the equations of motion bear on pitch and yaw alone. Angles of attack and sideslip due to translational velocities along the vertical and lateral axes of the aircraft are neglected, and so are changes of flight velocity and rolling velocity. The problem is thus reduced to two equations of moments about the lateral and vertical axes of the aircraft. These equations are expanded in terms of the undamped natural frequencies and the damping ratios of the aircraft about these axes (based on the pivot or single degree of freedom concept). Expansion of the resulting determinant leads to a quartic equation describing the stability of the aircraft.

The results of calculations are presented for several cases for which simplifying assumptions regarding moments of inertia and damping were made. It was found that rolling causes instability when the rolling velocity exceeds the lower, but not the higher, of the pitching and yawing undamped natural frequencies (expressed as circular frequencies in the same angular units as the rolling velocity) of the nonrolling airplane. If the rate of roll exceeds both the pitching and yawing natural frequencies of the nonrolling aircraft, the aircraft will be stable. A continuously rolling aircraft will be stable in this case even when the nonrolling aircraft has a certain amount of static instability about one axis.

W. O. Breuhaus, USA

1159. Robert S. Swanson, "Discussion of 'Progress in dynamic stability and control research,' by William F. Milliken, Jr.," *J. aero. Sci.*, May 1948, vol. 15, pp. 311–312.

In the original paper, the effects of the dynamic stability derivatives Z_q, M_w, and Z_δ were omitted in the extraction of other dynamic stability derivatives from flight test data. This was done for simplicity and because of their smallness. The discussion points out that there are cases in which the effect of these derivatives is not negligible. A method for taking account of them is given. Results of calculations on a B-25J airplane show a significant effect of Z_δ, but negligible effects of Z_q and M_w.

R. K. Koegler, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 1087, 1152)

1160. M. V. Barton, "Stability of an oscillating airfoil in supersonic airflow," *J. aero. Sci.*, June 1948, vol. 15, pp. 371–376.

For a flat plate in two-dimensional supersonic flow the limits of oscillatory stability are calculated and plotted in terms of the Mach number and reduced frequency. The graphs do not replace the usual flutter analyses, because the amplitude ratios are determined by the structural and inertial properties of the system.

John W. Miles, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1125, 1135, 1140, 1148, 1149, 1164)

1161. N. M. Markov, "Calculation of profile losses in reaction turbines and compressor grids for shock-free gas flow around them" (in Russian), *Notes Acad. Sci. USSR* (*Doklady Akad. Nauk SSSR*), May 1, 1948, vol. 60, pp. 555–558.

A profile loss formula for the flow of a compressible viscous fluid is derived from a previous paper, by the same author, dealing with an incompressible flow in a converging nozzle. In the present paper nondimensional loss coefficients for two types of grids, converging (turbine) and diverging (compressor), are introduced as $\zeta_v = E_v/E_{ad}$, where E_v is the energy loss in the grid and E_{ad} the energy of adiabatic expansion or compression.

The final expression for this coefficient is

$$\zeta_v = \frac{\rho_{oo}\Sigma H^{***}U^3\delta^{**}}{(G_o/g - \rho_{oo}\Sigma H^{*}U\delta^{**})c_o^2}$$

where δ^{**} is the thickness of the boundary layer computed from the velocity distribution on the outside surface of the boundary (it can be derived, for instance, from an electrohydrodynamic analogy, with a subsequent correction for compressibility). H^* and H^{***} are functions of δ^{**} and the boundary-layer thicknesses calculated separately for E_v and E_{ad}. These are determined by the law of variation of the velocities in the boundary layers, from experiment or by one of the analytic methods. G_o is the adiabatic discharge, c_o the fictitious velocity of the adiabatic compression computed from the pressure drop, ρ is the density, ρ_{oo} is a constant. Σ indicates the addition of two values, one for the convex surface, the other for the concave one.

D. Jacovleff, Belgium

Experimental Flow Equipment and Technique

(See also Rev. 1149)

1162. W. B. Huston, "Accuracy of air-speed measurements and flight calibration procedures," *Nat. adv. Comm. Aero. tech. Note*, no. 1605, June 1948, pp. 1–80.

The results of 97 papers (15 figures) dealing with the errors encountered in the measurement of flight Mach number and true air speed are brought together in this useful reference work. Errors in the measurement of static pressure, total pressure, and temperature due to instrument position, angle of attack, and time lag are discussed.

C. A. Meyer, USA

1163. F. W. Barry and G. M. Edelman, "An improved schlieren apparatus," *J. aero. Sci.*, June 1948, vol. 15, pp. 364–365.

This paper describes a schlieren apparatus which forms and photographs two separate images of the test section simultaneously, one image indicating, say, vertical density gradients, the other indicating horizontal density gradients. This is accomplished by splitting the light from a single source, by means of an aluminized glass block, into a horizontal beam and a vertical beam. By means of suitable mirrors, these light beams are directed through the test section, thence past two mutually perpendicular knife edges, and subsequently to the camera. The simultaneous recording of the two images is particularly useful under nonsteady flow conditions.

John E. Goldberg, USA

1164. W. Stewart, "Flight testing of helicopters," *J. roy. aero. Soc.*, May 1948, vol. 52, pp. 261–304.

In a comprehensive and scholarly paper, the author deals with helicopter flight testing under four important headings: (1) Flow through the rotor disk; (2) performance testing; (3) stability and control; (4) blind flying. In investigation of flow through the rotor disk, the author used a smoke generator for visualizing flow, and a double venturi for measuring low velocities, and studied the vortex ring and other interesting conditions. In performance testing the author gave attention to such points in technique as the best placing of the pitot tube and studied vertical flight and ground effect. The tests in stability and control were accompanied by curves of cyclical pitch distribution and altitude time histories. Dynamic stability and oscillations were studied.

A valuable part of the paper is the comparison of the experiments in dynamic stability with theoretical calculations based on the work of G. J. Sissingh. Under blind flying the paper compares the helicopter and the airplane. Among other instruments an aerodynamic means of sideslip indication (using a hemispherical type of head) was tried and found satisfactory.

Alexander Klemin, USA

Lubrication; Wear

1165. A. T. Gwathmey, H. Leidheiser, and G. P. Smith, "Influence of crystal plane and surrounding atmosphere on chemical activities of single crystals of metals," *Nat. adv. Comm. Aero. tech. Note*, no. 1460, June 1948, pp. 1–67.

This paper gives a general survey of the influence of crystal plane on the chemistry of oil on metal surfaces. The properties of crystal orientation and its effect on surface reaction and reaction rates have been considered for 13 metals, including: (1) face-centered cubic structure—aluminum, copper, gold, lead, nickel, and silver; (2) body-centered cubic structure—chromium and iron; (3) hexagonal close-packed structure—cadmium and zinc; (4) rhombohedral structure—bismuth; (5) body-centered tetragonal structure—tin; (6) face-centered tetragonal structure—indium.

The chemical reactions and reaction rates which have been considered are as follows: (1) Oxidation in air, (2) corrosion by oils, including the amount of metal removed and the areas which are roughened, (3) wetting of the surface by stearic acid on copper, nickel, and iron, (4) rearrangement and roughening of the surface due to the action of hot gases, (5) electrochemical processes, including deposition, etching, replacement, and galvanic action.

This paper is very comprehensive. Preparation of the samples, including the preparation of single crystals of all of the metals, is discussed in detail. The methods of preparing the surfaces and some of the problems encountered are presented. Illustrations are given showing the results of some of the tests in which the difference in chemical action of the different crystal planes is clearly evident.

Perhaps the most important point which is made in this paper is that the variation in these reactions is greater from one plane to another in the same crystal than it is from one crystal or one material to another. It is also made clear that these reactions must be understood in considering problems of friction and wear.

Erle I. Shobert, 2nd, USA

Dynamics of Meterology and Oceanography

(See also Revs. 1092, 1168)

1166. **F. C. E. Oder, "The magnitude of radiative heating in the lower stratosphere,"** *J. Met.*, Apr. 1948, vol. 5, pp. 65–67.

The problem discussed is the determination of the order of magnitude of nonadiabatic temperature changes in the lower stratosphere, due to radiative processes. Calculations of heat-flux divergence are made on a synthesized model by dividing the atmosphere between 10 and 50 km into layers with assumed uniform temperature and absorber distribution. Results of the calculations, which are made for three bands of 0_3 in the infrared and for two bands of CO_2 in the infrared, indicate that the time rate of change of potential temperature due to radiative processes increases from 10^{-6} (degrees absolute per second) in the lower 15 km to 10^{-3} in the layers from 35 to 47 km, and decreases to 10^{-5} in the uppermost 3 km. Warren M. Rohsenow, USA

Ballistics; Detonics (Explosions)

(See Rev. 1151)

Thermodynamics

(See also Revs. 1127, 1161)

1167. **Herbert B. Callen, "The application of Onsager's reciprocal relations to thermoelectric, thermomagnetic, and galvanomagnetic effects,"** *Phys. Rev.*, June 1, 1948, vol. 73, pp. 1349–1358.

Analysis of the thermoelectric, thermomagnetic, and galvanomagnetic effects by means of the reciprocal relations of Onsager leads to a simple and intuitive interpretation of the thermoelectric effects, provides a valid derivation of the Kelvin relations, and answers the long standing question as to the existence of relations among the effects in a magnetic field.

For a set of irreversible processes expressible as rates of change of a set of measurable parameters, α_i, assume that the macroscopic laws governing the processes (such as Ohm's Law, etc.) can be expressed in linear form

$$\partial\alpha_i/\partial t = \Sigma_j L_{ij}(\partial s/\partial\alpha_j)$$

where t is time, s is entropy, and the L's are "kinetic coefficients" which are functions of the state of the system. Then Onsager's theorem states that $L_{ij}(H) = L_{ji}(-H)$ where H is the applied magnetic (or Coriolis) field.

The derivation of the Onsager relations strictly refers only to a specific type of transient irreversible process but may be applied to steady state processes by utilizing the "method of local equilibrium." It leads to the following expressions for the thermoelectric coefficients: π_{AB} (Peltier) $= (T/e)(S_{J_B} - S_{J_A})$: τ (Thomson) $= (T/e)(dS_J/dT)$: ϵ_{AB} (Thermoelectric power) $= (1/e)(S_{J_B} = S_{J_A})$. From these relations the Kelvin equations $\pi_{AB} = T\epsilon_{AB}$, $\tau_B - \tau_A = T(d\epsilon_{AB}/dT)$ are immediately obtained. Here T is absolute temperature, e charge on the particle, S_J is an entropy flow per particle, and A and B refer to two dissimilar materials.

Onsager's method shows that among eight commonly defined coefficients applicable to a magnetic field there exist two independent relations, of which the more important one has been previously given by Bridgman. Warren M. Rohsenow, USA.

Heat Transfer

(See also Rev. 1166)

1168. **K. Terada and G. Yamamoto, "Method for measuring air temperature on a high-speed airplane,"** *J. Met.*, Dec. 1947, vol 4, pp. 201–202.

A thermometer at the thermally insulated wall of the throat of a Venturi should measure the true mean-stream temperature of the fluid at the Venturi inlet provided the inlet diameter D_i, the throat diameter D_t, and the recovery factor r are related by $(D_t/D_i)^4 = 1 - r$. Assuming $r = 0.85$, an instrument was constructed with $D_t/D_i = 0.62$. Suspended below an airplane, it indicated a temperature rise of but 0.7 C when the speed changed from 250 to 400 km per hr, proving that this type of instrument indicates true air temperature without large error. Further work is needed to confirm the value of r.

While the theory neglects the compressibility effect, and does not apply to very fast airplanes, it seems satisfactory for most modern planes.

The reviewer notes that for an incompressible fluid with inlet speed of 400 km per hr the throat speed would be 1540 km per hr. It is not obvious that air may be considered incompressible when the calculated speed is much greater than that of sound.

Benjamin Miller, USA

Periodicals Now Being Regularly Scanned

THERE have been many inquiries about the magazines being scanned to produce APPLIED MECHANICS REVIEWS. It had been intended to publish a list of the periodicals at the end of the year. However, from the numerous inquiries received it seems advisable to publish this list now and supplementary lists at the end of the year to cover those not included in this list.

The following information is given: The abbreviation used in APPLIED MECHANICS REVIEWS; full name; frequency of publication; address of publisher; language in which published when this is not evident from the country. The Editorial Office will appreciate receiving the name and publisher's address of any other publication in the field of applied mechanics which we should cover.

A

Acta Math.—Acta Mathematica; bimonthly; Geodetic Institute Copenhagen, Denmark (in English, French, or German).

Aero. Engng. Rev.—Aeronautical Engineering Review; monthly; Institute of the Aeronautical Sciences Inc., 2 E. 64th Street, New York 21, New York, U.S.A.

Aerotecnica—L'Aerotecnica; bimonthly; Associazione Italiane di Aerotecnica, Piazza S. Bernardo 101, Rome, Italy (in Italian with English abstracts).

Aircr. Engng.—Aircraft Engineering; monthly; Bunhill Publications Ltd., 12 Bloomsbury Square, London W C 1, England.

Amer. Soc. Test. Mat. Bull.—American Society for Testing Materials Bulletin; bimonthly; American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania, U.S.A.

Angew. Chem. B—Angewandte Chemie, part B, Technische-Wirtschaftlicher Teil; bimonthly; Verlag Chemie G.m.b.H., Weinheim/Bergstrasse, Germany.

Ann. Mat. pura appl.—Annali di Matematica Pura ed Applicata; annually; Nicholas Zanichelli, Editore, Via Garibaldi 3, Bologna, Italy.

Ann. Min. Belg.—Annales des Mines de Belgique; quarterly; Imprimerie Robert Louis, 37-39 rue Borrens, Bruxelles, Belgium (in French and Flemish).

Ann. Ponts Chauss.—Annales Ponts et Chaussees; bimonthly; Jacques Dumas, Éditeur, 5 rue Jules-Lefebvre, Paris, France.

Ann. Soc. sci. Brux. Sér. I—Annales de la Société Scientifique de Bruxelles, Série I, Sciences Mathématique, Astronomique et Physiques; three issues per year; Secrétariat de la Société Scientifique, 11 Rue des Récollets, Louvain, Belgium (in French).

Appl. Math. Mech. (Prikl. Mat. Mekh.)—Applied Mathematics and Mechanics; bimonthly; Academy of Sciences of the U.S.S.R., Moscow, Russia.

Appl. sci. Res. Sec. A—Applied Scientific Research, Section A, Mechanics, Heat; irregular; Martinus Nijhoff, 9 Lange Voorhout, The Hague, Netherlands (in English, French, or German).

Appl. sci. Res. Sec. B—Applied Scientific Research, Section B, Electrophysics, Acoustics, Optics; irregular; Martinus Nijhoff, 9 Lange Voorhout, The Hague, Netherlands (in English, French, or German).

Arch. Mat. Astr. Fys.—Archiv för Matematik, Astronomi och Fysik; quarterly; Almqvist & Wiksells Boktryskerie A.B., Stockholm, Sweden (in English, French, or German).

ATI tech. Data Dig.—Air Technical Intelligence Technical Data Digest; semimonthly; Air Documents Division, Intelligence Department, Air Materiel Command, Wright Field, Dayton, Ohio, U.S.A.

Atti Accad. Torino—Atti della Accademia delle Scienze di Torino; irregular; Accademia della Scienze, Via Accademia della Scienze 6, Torino, Italy.

Austral. Counc. Aero. Rep.—Australian Council for Aeronautics Reports; irregular; Australian Council for Aeronautics, Box 4331, G.P.O., Melbourne, Australiâ.

Auto. Engr.—Automobile Engineer; monthly; Iliffe & Sons Ltd., Dorset House, Stamford Street, London S E 1, England.

Auto.-tech. Z.—Automobiltechnische Zeitschrift; bimonthly; Franckh'sche Verlagshandlung Abt. Technik., Pfisterstr. 5-7, Stuttgart O, Germany.

B

B. C. res. Counc. tech. Bull.—British Columbia Research Council Technical Bulletin; irregular; British Columbia Research Council, University of British Columbia, Vancouver, B. C., Canada.

Babcock Wilcox Co. Bull.—Babcock and Wilcox Company Bulletin; irregular; Babcock and Wilcox Company, 85 Liberty Street, New York 6, New York, U.S.A.

Bâtim. Trav. publics—Institut Technique du Bâtiment et des Travaux Publics Publications, published since January, 1948, as Annales de l'Institut Technique du Bâtiment et des Travaux Publics; irregular; Institut Technique du Bâtiment et des Travaux Publics, 28 Blvd. Raspail, Paris VII, France.

Bauplan. Bautech.—Bauplanung und Bautechnik; monthly; Verlag Technik, G.m.b.H., Dorotheenstr. 41, Berlin N W 7, Germany.

Bautechnik—Die Bautechnik; monthly; Verlag Wilhelm Ernst & Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany.

Boll. Un. mat. ital.—Bollettino della Unione Matematica Italiana; three issues per year; Unione Matematica Italiana, Bologna, Italy.

Brown Boveri Rev.—The Brown Boveri Review; monthly; Brown, Boveri & Co. Ltd., Baden, Switzerland (in English).

Bul. Soc. polit. român.—Buletinul Societăţii Politecnice din România; quarterly; Societăţii Politecnice, Calea Victoriei 118 Et. I, Bucaresti III, Roumania.

Bull. Acad. Belg. Cl. Sci.—Bulletin de l'Académie R. de Belgique, Classe des Science; monthly; Académie Royale de Belgique, Palais des Académies, Rue Ducale 1, Bruxelles, Belgium (in French and Flemish).

Bull. Acad. Sci. URSS (Ser. techn. Sci.)—see Bull. Acad. Sci. USSR Ser. tech. Sci. (Izv. Akad. Nauk SSSR Ser. tekh. Nauk).

Bull. Acad. Sci. USSR Ser. Phys. (Izv. Akad. Nauk SSSR Ser. Fiz.)—Bulletin of the Academy of Sciences, Series Physics; bimonthly; Academy of Sciences of the U.S.S.R., Moscow, Russia.

Bull. Acad. Sci. USSR Ser. tech. Sci. (Izv. Akad. Nauk SSSR Ser. tekh. Nauk)—Bulletin of the Academy of Sciences, Series Technical Science; monthly; Academy of Sciences of the U.S.S.R., Moscow, Russia.

Bull. Amer. ceram. Soc.—Bulletin of the American Ceramic Society; monthly; American Ceramic Society, 2525 N. High Street, Columbus 2, Ohio, U.S.A.

Bull. Amer. math. Soc.—Bulletin of the American Mathematical Society; monthly; American Mathematical Society, 531 W. 116th Street, New York 27, New York, U.S.A.

Bull. Amer. Rly. engng. Ass.—Bulletin of the American Railway Engineering Association; seven issues per year; American

Railway Engineering Association, 59 E. Van Buren Street, Chicago 5, Illinois, U.S.A.

Bull. Ass. suisse Elect.—Bulletin de l'Association Suisse des Electriciens; semimonthly; Association Suisse des Electriciens, Seefeldstrasse 301, Zurich 8, Switzerland (in German or French).

Bull. Calcutta Math. Soc.—Bulletin of the Calcutta Mathematical Society; quarterly; Calcutta Mathematical Society, 92 Upper Circular Road, Calcutta, India (in English).

Bull. Ec. polyt. Jassy—Bulletin de l'École Polytechnique de Jassy; semiannually; M. le Prof. D. I. Mangeron, Directeur du Seminaire Mathématique de l'École Polytechnique de Jassy, Jassy-Iasi, Roumania (in French, English, or Roumanian).

Bull. Lpool. engng. Soc.—Bulletin of the Liverpool Engineering Society; monthly; Liverpool Engineering Society, 9 The Temple, Dale Street, Liverpool, England.

Bull. math. Soc. roum. Sci.—Bulletin Mathématique de la Société Roumaine des Sciences; irregular; Facultatei de Stiinte, Str. Academiei 14, Bucaresti, Roumania (in French, or German).

Bull. Oerlikon—Bulletin Oerlikon; bimonthly; Ateliers de Construction Oerlikon; Zurich Oerlikon, Switzerland (in English).

Bull. sci. Ec. polyt. Timisoara—Bulletin Scientifique de l'École Polytechnique de Timisoara; semiannually; Bulletin de Science et Technique de la Polytechnique de Timisoara, Timisoara, Roumania (in Roumanian, French, or English).

Bull. Sec. Sci. Acad. roum.—Bulletin de la Section Scientifique de l'Académie Roumaine; irregular; Academie Română, Calea Victoriei 125, Bucaresti, Roumania (in French or German).

Bull. Sécheron—Bulletin Sécheron; irregular; S. A. des Ateliers de Sécheron, Geneva, Switzerland (in French).

Bull. Soc. math. Fr.—Bulletin de la Société Mathématique de France; quarterly; M. Leray, Institut Henri Poincaré, 12 rue Pierre-Curie, Sceaux, France.

Bull. Soc. math. Grèce—Bulletin de la Société Mathématique de Grèce; quarterly; President of the Administrative Board of E.M.E., Prof. Sakellariou N., 3 Voulis Str., Athens, Greece (in Greek, English, or French).

Bull. Tech. Vevey—Bulletin Technique Vevey; irregular; Ateliers de Constructions Mécaniques de Vevey, S.A., Vevey, Switzerland (in French).

C

C. R. Acad. Sci. Paris—Comptes Rendus Hebdomadaires des Seances de l'Académie de Sciences; weekly; Gauthier Villars, Imprimeur-Librarie des Comptes Rendus des Seances de l'Académie des Sciences, 55 Quai des Grands-Augustins, Paris, France.

C. R. Acad. Sci. URSS—published since November, 1947, as Notes Acad. Sci. USSR (Doklady Akad. Nauk SSSR) which see.

Canad. J. Res. Sec. A—Canadian Journal of Research, Section A Physical Sciences; bimonthly; National Research Council, Ottawa, Ontario, Canada.

Canad. J. Res. Sec. F—Canadian Journal of Research, Section F Technology; bimonthly until January, 1948, monthly subsequently; National Research Council, Ottawa, Ontario, Canada.

Chin. J. Phys.—Chinese Journal of Physics; semiannually; K. G. Ku, National Academy of Peiping, 42 Tung Huang Cheng Ken, Peiping, China (in English).

Ciene. Tecn.—Ciencia y Tecnica, Revista del Centro Estudiantes de Ingeniería; monthly; Centro Estudiantes de Ingeniería, Peru 272, Buenos Aires, Argentina.

Ciencia Tecn.—see Ciene. Tecn.

Civ. Engng. Lond.—Civil Engineering; monthly; Lomax, Erskine & Co., Ltd., 154 Fleet Street, London E C 4, England.

Civ. Engng. N. Y.—Civil Engineering; monthly; American Society of Civil Engineers, 33 W. 39th Street, New York 18, New York, U.S.A.

Coll. Aero. Rep.—The College of Aeronautics Reports; irregular; College of Aeronautics, Cranfield, Bletchley, Bucks, England.

Commun. appl. Math.—Communications on Applied Mathematics; quarterly; Interscience Publishers, Inc., 215 Fourth Avenue, New York, New York, U.S.A.

Cornell Univ. engng. Exp. Sta. Bull.—Cornell University Engineering Experiment Station Bulletin; irregular; Cornell University Press, 124 Roberts Place, Ithaca, New York, U.S.A.

Curr. Sci.—Current Science; monthly; The Secretary, Current Science Association, Malleswaram P. O., Bangalor, India (in English).

D

David Taylor Model Basin Rep.—Reports of the David Taylor Model Basin, United States Navy; irregular; Director, David Taylor Model Basin, U.S.N., Washington 7, D. C., U.S.A.

E

Earthq. Notes eastern Sec. seism. Soc. Amer.—Earthquake Notes, Eastern Section, Seismological Society of America; irregular; U. S. Coast and Geodetic Survey, Washington 25, D. C., U.S.A.

Eidgenöss. MatPrüfAnst. Ber.—Eidgenössische Materialprüfungs- und Versuchsanstalt für Industrie, Bauwesen und Gewerbe Bericht; irregular; Eidgenössische Materialprüfungs- und Versuchsanstalt für Industrie, Bauwesen und Gewerbe, Zurich, Switzerland (in French or German).

Energia Elett.—L'Energia Elettrica; monthly; Via Revere 14, Milan, Italy.

Engineer Lond.—The Engineer; weekly; 28 Essex Street, Strand, London W C 2, England.

Engineering—Engineering; weekly; 35-36 Bedford Street, Strand, London W C 2, England.

Engng. Bull. Purdue Univ. Res. Ser.—Engineering Bulletin Purdue University, Research Series; irregular; Purdue University, West Lafayette, Indiana, U.S.A.

Engng. J. Montreal—The Engineering Journal; monthly; Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Engng. News Rec.—Engineering News-Record; weekly; Director of Circulation, McGraw-Hill Publishing Co., Inc., 330 W. 42nd Street, New York 18, New York, U.S.A.

F

Flygtekn. Försöksanst. Medd.—Flygtekniska Försöksanstalten Meddelande; irregular; Royal Swedish Air Board, Material Division, Stockholm, Sweden (in Swedish with English summaries or English).

G

G. Gen. civ.—Giornale del Genio Civile; monthly; Istituto Poligrafico dello Stato, Libreria dello Stato, Roma, Italy.

Gas Wasserfach—Die Gas- und Wasserfach; irregular; Leibniz Verlag, Schliessfach 31, München 1, Germany.

Génie civ.—Le Génie Civil; semimonthly; 5 rue Jules-Lefebvre, Paris 9, France.

Géotechnique Lond.—Géotechnique; monthly; Geotechnical Society, 123 Victoria Street, London S W 1, England.

Glasers Ann.—Glasers Annalen; monthly; Georg Siemens Verlagsbuchhandlung, Nollendorfstrasse 28, Berlin W 30, Germany.

H

Hdqtrs. Air Mat. Comm. Dayton Tech. Rep.—Air Materiel Command Technical Reports; irregular; Air Materiel Command, Wright Field, Dayton, Ohio, U.S.A.

Hdqtrs. Air Mat. Comm. Dayton Transl.—Air Materiel Command Translation; irregular; Air Materiel Command, Wright Field, Dayton, Ohio, U.S.A.

Hdqtrs. Air Mat. Comm., Wright Field, Dayton, Ohio, Tech. Rep.—see Hdqtrs. Air Mat. Comm. Dayton Tech. Rep.

Heat. Pip. Air Condit.—Heating, Piping and Air Conditioning; monthly; Keeney Publishing Co., 6 N. Michigan Ave., Chicago 2, Illinois, U.S.A.

Helv. phys. Acta—Helvetica Physica Acta; bimonthly; Éditions Birkhauser S.A., Schweizerische Physikalische Gesellschaft, Basel, Switzerland (in German or French).

Houille blanche—La Houille Blanche; bimonthly; Éditions B. Arthaud, 23 Grande-Rue, Grenoble, France.

Hung. Acta Math.—Hungarica Acta Mathematica; irregular; Hungarian Academy of Sciences, Akademia-utca 2, Budapest V, Hungary (in English, German, or French).

I

Indian J. Phys.—Indian Journal of Physics; monthly; Indian Association for the Cultivation of Science, 210 Bowbazar Street, Calcutta, India (in English).

Indust. ceram.—L'Industrie Ceramique; monthly; Société d'Éditions Scientifiques, Techniques et Artistiques, 6 Avenue de Madrid, Neuilly-sur-Seine, France.

Ingen.-Arch.—Ingenieur-Archiv; irregular; Springer-Verlag, Jebensstrasse 1, Berlin-Charlottenburg 2, Germany.

Igenieur 's-Gravenhage—De Ingenieur; weekly; Prinsessegracht 23, 's-Gravenhage, Holland (in Dutch with English summaries).

IngenVetenskAkad. Tidsk. Tekn. Forsk.—Ingeniörsvetenskapsakademien Tidskrift för Teknisk-Vetenskaplig Forskning; bimonthly; Professor Edy Velander, Ingeniörsvetenskapsakademien, Stockholm 5, Sweden (in Swedish or English).

Inst. Sup. Técn. Lisbon Publ.—Institut Superior Técnico Lisbon Publicação; irregular; Laboratorio de Engenharia Civil, Av^{a} Rovisco Pais, I. S. Técnico, Pavilhao Principal, Canto N E, Lisboa, Portugal (in Portuguese with English summaries).

Inst. tecn. Constr. Edific. Publ.—Instituto Tecnico de la Construccion y Edificacion Publications; irregular; Consejo Superior de Investigaciones Cientificas, Ruiz de Alarcon 25, Madrid, Spain.

Instruments—Instruments; monthly; Instruments Publishing Co., Inc., 1117 Wolfendale Street, Pittsburgh 12, Pennsylvania, U.S.A.

Intermêd. Rech. Math.—Intermédiare des Recherches Mathématiques; quarterly; Hermann & Cie, Éditeurs, 55 rue de Varenne, Paris 7^{e}, France.

Inzyn. Budown.—Inzynieria i Budownictwo; monthly; Polskiego Zwiazku Inzynierów Budowlanych, ul. Narbutta 26 II-gie p., Warsaw, Poland.

J

J. acoust. Soc. Amer.—The Journal of the Acoustical Society of America; bimonthly; American Institute of Physics, Inc., 57 E. 55th Street, New York 22, New York, U.S.A.

J. aero. Sci.—Journal of the Aeronautical Sciences; bimonthly; Institute of the Aeronautical Sciences, Inc., 2 E. 64th Street, New York 21, New York, U.S.A.

J. Amer. ceram. Soc.—The Journal of the American Ceramic Society; monthly; American Ceramic Society, 2525 N. High Street, Columbus 2, Ohio, U.S.A.

J. Amer. Concr. Inst.—The Journal of the American Concrete Institute; monthly; American Concrete Institute, New Center Building, Detroit 2, Michigan, U.S.A.

J. Amer. Soc. nav. Engrs.—Journal of the American Society of Naval Engineers; quarterly; American Society of Naval Engineers, Inc., Navy Department, Washington, D. C., U.S.A.

J. Amer. Weld. Soc.—Journal of the American Welding Society; monthly; American Welding Society, 33 W. 39th Street, New York 18, New York, U.S.A.

J. appl. Mech.—Journal of Applied Mechanics; quarterly; American Society of Mechanical Engineers, 29 W. 39th Street, New York 18, New York, U.S.A.

J. appl. Phys.—Journal of Applied Physics; monthly; American Institute of Physics, Inc., 57 E. 55th Street, New York 22, New York, U.S.A.

J. Colloid Sci.—Journal of Colloid Science; bimonthly; Academic Press, Inc., 125 E. 23rd Street, New York 10, New York, U.S.A.

J. exp. theor. Phys. (Zh. eksp. teor. Fiz.)—Journal of Experimental and Theoretical Physics; monthly; Academy of Sciences of the U.S.S.R., Moscow, Russia.

J. Franklin Inst.—Journal of the Franklin Institute; monthly; Franklin Institute of the State of Pennsylvania, Benjamin Franklin Parkway at 20th Street, Philadelphia 3, Pennsylvania, U.S.A.

J. Inst. Metals—The Journal of the Institute of Metals; monthly; Institute of Metals, 4 Grosvenor Gardens, London S W 1, England.

J. Instn. civ. Engrs.—Journal of the Institution of Civil Engineers; monthly; Institution of Civil Engineers, Great George Street, London S W 1, England.

J. Iron Steel Inst.—Journal of the Iron and Steel Institute; monthly; Iron and Steel Institute, 4 Grosvenor Gardens, London S W 1, England.

J. Mar. Res.—Journal of Marine Research; three issues per year; Sears Foundation for Marine Research, Bingham Oceanographic Laboratory, Yale University, New Haven, Connecticut, U.S.A.

J. Math. Phys.—Journal of Mathematics and Physics; quarterly; Massachusetts Institute of Technology, Cambridge 39, Massachusetts, U.S.A.

J. Math. pures appl.—Journal de Mathématiques pures et Appliquées; quarterly; Gauthier-Villars, Imprimerie-Libraire, 55 Quai des Grands-Augustins, Paris, France.

J. Met.—Journal of Meteorology; bimonthly; American Meteorological Society, 5 Joy Street, Boston 8, Massachusetts, U.S.A.

J. opt. Soc. Amer.—Journal of the Optical Society of America; monthly; American Institute of Physics, 57 E. 55th Street, New York 22, New York, U.S.A.

J. Phys. Acad. Sci. USSR (Zh. Fiz. Akad. Nauk SSSR)—Journal of Physics, Academy of Sciences of the U.S.S.R; monthly; Academy of Sciences of the U.S.S.R., Kaluzhskoeshosse 32, Moscow, Russia.

J. Polymer Sci.—Journal of Polymer Science; bimonthly; Interscience Publishers, Inc., 215 Fourth Ave., New York 3, New York, U.S.A. (in English, French, or German).

J. Res. nat. Bur. Stands.—Journal of Research, National Bureau of Standards; monthly; Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., U.S.A.

J. roy. aero. Soc.—Journal of the Royal Aeronautical Society; monthly; Royal Aeronautical Society, 4 Hamilton Place, Picadilly, London W 1, England.

J. sci. Instrum.—Journal of Scientific Instruments and of Physics in Industry; monthly; Institute of Physics, 47 Belgrave Square, London S W 1, England.

J. tech. Phys. (*Zh. tekh. Fiz.*)—Journal of Technical Physics; monthly; Academy of Sciences of the U.S.S.R., Moscow, Russia.

J. Wash. Acad. Sci.—Journal of the Washington Academy of Sciences; monthly; Harald A. Rehder, Subscription Manager of Publications, U. S. National Museum, Washington 25, D. C., U.S.A.

Jernkontor. Ann.—Jernkontorets Annaler; monthly; Kungstradgardsgaten 6, Stockholm C, Sweden (in Swedish with English summaries).

L

L'Aerotecnica—see Aerotecnica

M

Mach. Métaux—Machines et Métaux; monthly; Science et Industrie, 6 Avenue Pierre 1er de Serbie, Paris XVI, France.

Mater. Meth.—Materials and Methods; monthly; Reinhold Publishing Corp., 330 W. 42nd Street, New York 18, New York, U.S.A.

Math. Gaz.—The Mathematical Gazette; irregular; Hon. Treasurer, Mathematical Association, Gordon House, 29 Gordon Square, London W C 1, England.

Mathesis Brux.—Mathesis; five issues per year; Jules Duculot Imprimeur-Éditeur, 11 Rue Léopold, Gembloux, Belgium (in French).

Mech. Engng.—Mechanical Engineering; monthly; American Society of Mechanical Engineers, 29 W. 39th Street, New York 18, New York, U.S.A.

Medd. SkeppsProvAnst. Göteborg—Meddelanden fran Statens Skeppsprovningsanstalt; irregular; Statens Skeppsprovningsanstalt, Göteborg 9, Sweden (in Swedish with English summaries or English).

Mémor. Artill. fr.—Mémorial de l'Artillerie Française; quarterly; l'Imprimerie Nationale, 27 rue de la Convention, Paris 15, France.

Metal Progr.—Metal Progress; monthly; American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio, U.S.A.

Metal Treatm.—Metal Treatment; quarterly; 49 Wellington Street, Strand, London W C 2, England.

Metall—Metall; monthly; Metall-Verlag G.m.b.H., Dusseldorfer Str. 38, Berlin W 15, Germany.

Metallurgia—Metallurgia; monthly; Kennedy Press Ltd., Bedford Street, London W C 2, England.

Metallurgia ital.—La Metallurgia Italiana; bimonthly; L'Associazione Italiana di Metallurgia, Via S. Paolo 10, Milano, Italy.

Milit. Engr.—The Military Engineer; monthly; Society of American Military Engineers, Mills Building, Washington 6, D. C., U.S.A.

Mod. Plastics—Modern Plastics; monthly; Plastics, Inc., 20th & Northhampton Streets., Easton, Pennsylvania, U.S.A.

Monogr. sci. Aero.—Monographie Scientifiche di Aeronautica; irregular; Magg. G.A.R.I. Luigi Broglio, Segretario del Comitato, Divisione Studi della Direzione della Construzioni, Ministero della Difesa-Aeronautica, Valle dell'Universita, Roma, Italy.

Monogr. sci. Aero. Suppl. Tecn.—Monografie Scientifiche di Aeronautica Supplementi Technici; irregular; Magg. G.A.R.I. Luigi Broglio, Segretario del Comitato, Divisione Studi della Direzione della Construzioni, Ministero della Difesa-Aeronautica, Valle dell'Universita, Roma, Italy.

N

Nat. adv. Comm. Aero. Rep.—National Advisory Committee for Aeronautics Report; irregular; Division of Research Information, National Advisory Committee for Aeronautics, Washington, D. C., U.S.A.

Nat. adv. Comm. Aero. tech. Memo.—National Advisory Committee for Aeronautics Technical Memorandum; irregular; Division of Research Information, National Advisory Committee for Aeronautics, Washington, D. C., U.S.A.

Nat. adv. Comm. Aero. tech. Note—National Advisory Committee for Aeronautics Technical Note; irregular; Division of Research Information, National Advisory Committee for Aeronautics, Washington, D. C., U.S.A.

Nat. Advis. Comm. for Aero. Rep.—see Nat. adv. Comm. Aero. Rep.

Nat. Advis. Comm. for Aero. Tech. Memo.—see Nat. adv. Comm. Aero. tech. Memo.

Nat. Advis. Comm. for Aero. Tech. Note—see Nat. adv. Comm. Aero. tech. Note.

Nat. LuchtLab. Amsterdam Rap.—Nationaal Luchtvaartlaboratorium Rapport; irregular; Nationaal Luchtvaartlaboratorium, Sloterweg 145, Amsterdam W, Holland (in Dutch with English summaries or English).

Nat. Res. Counc. Can. Aero. Note—National Research Council of Canada Aeronautical Note; irregular; Division of Mechanical Engineering, National Research Council, Ottawa, Ontario, Canada.

Nat. Res. Counc. Can. Aero. Rep.—National Research Council of Canada Aeronautical Report; irregular; Division of Mechanical Engineering, National Research Council, Ottawa, Ontario, Canada.

Nature Lond.—Nature; weekly; MacMillan & Company Ltd., St. Martin's Street, London W C 2, England.

Notes Acad. Sci. USSR (*Doklady Akad. Nauk SSSR*)—Notes of the Academy of Sciences of the U.S.S.R.; three issues per month; Academy of Sciences of the U.S.S.R., Moscow, Russia.

Nucleonics—Nucleonics; monthly; McGraw-Hill Publishing Company, Inc., 330 W. 42nd Street, New York 18, New York, U.S.A.

Nuovo Cim.—Il Nuovo Cimento; bimonthly; Societa Italiana di Fisica, L'Istituto di Fisica dell'Universita, Via Irnerio no. 46, Bologna, Italy.

O

Ossature métallique—L'Ossature Métallique; eleven issues per year; M. Léon G. Rucquoi, 30 Rockefeller Plaza, New York 20, New York, U.S.A., or Centre Belgo-Luxembourgeois d'Information de l'Acier, 38 Boul. Bischoffsheim, Bruxelles, Belgium (in French).

Öst. Ingen.-Arch.—Österreichisches Ingenieur-Archiv; irregular; Springer Verlag, Mölkerbastei 5, Wein I, Austria.

P

Pedology (Pochvovedenie)—Pedology; monthly; Academy of Sciences of the U.S.S.R., Moscow, Russia.

Phil. Mag.—The Philosophical Magazine; Taylor & Francis Ltd., Red Lion Court, Fleet Street, London E C 4, England.

Philips tech. Rev.—Philips Technical Review; monthly; Elsevier Book Co., Inc., 215 Fourth Ave., New York 3, New York, U.S.A., or Research Laboratory, N. V. Philips' Gloeilampenfabrieken, Eindhoven, Holland (in English).

Phys. Rev.—The Physical Review; semimonthly; American Institute of Physics, 57 E. 55th Street, New York 22, New York, U.S.A.

Physica Hague—Physica; ten issues per year; Prof. Dr. A. D. Fokker, Natuurkundig Laboratorium van Teylers Stichting, Damstratt 21, Haarlem, Holland (in English or French).

Proc. Amer. Acad. Arts Sci.—Proceedings of the American Academy of Arts and Sciences; irregular; American Academy of Arts and Sciences, 28 Newbury Street, Boston, Massachusetts, U.S.A.

Proc. Amer. Soc. civ. Engrs.—Proceedings of the American Society of Civil Engineers; ten issues per year; American Society of Civil Engineers, 33 W. 39th Street, New York 18, New York, U.S.A.

Proc. Camb. phil. Soc.—Proceedings of the Cambridge Philosophical Society; quarterly; Cambridge Philosophical Society, Cambridge University Press, Bentley House, 200 Euston Road, London N W 1, England.

Proc. Instn. mech. Engrs.—Proceedings of the Institution of Mechanical Engineers; irregular; Institution of Mechanical Engineers, Storey's Gate, St. James Park, London S W 1, England.

Proc. int. Conf. soil Mech. found. Engng.—Proceedings of the International Conference on Soil Mechanics and Foundation Engineering; irregular; Gebr. Keesmalt, Haarlem, Netherlands (in English).

Proc. kon. Ned. Akad. Wet.—Proceedings Koninklijke Nederlandsche Akademie van Wetenschappen; monthly; North-Holland Publishing Company, Amsterdam, Holland (in English, French, German, or Dutch).

Proc. nat. Acad. Sci. Wash.—Proceedings of the National Academy of Sciences of the United States of America; monthly; Treasurer, National Academy of Sciences, Constitution Ave. and 21st St., Washington 25, D. C., U.S.A.

Proc. of Soc. for Exp. Stress Anal.—see Proc. Soc. exp. Stress Anal.

Proc. phys. Soc. Lond.—Proceedings of the Physical Society; bimonthly until January, 1948, monthly subsequently; The Physical Society, 1 Lowther Gardens, Prince Consort Road, London S W 7, England.

Proc. roy. Irish Acad. Sec. A—Proceedings of the Royal Irish Academy, Section A; irregular; Hodges, Figgis & Company, Dublin, Ireland (in English).

Proc. roy. Soc. Lond. Ser. A—Proceedings of the Royal Society, Series A, Mathematical and Physical Sciences; irregular; Cambridge University Press, Bentley House, 200 Euston Road, London N W 1, England.

Proc. Soc. exp. Stress Anal.—Proceedings of the Society for Experimental Stress Analysis; semiannually; Society for Experimental Stress Analysis, Central Square Station, P. O. Box 168, Cambridge 39, Massachusetts, U.S.A.

Proc. Vict. Inst. Engrs.—Proceedings of the Victorian Institute of Engineers; irregular; Victorian Institute of Engineers, Melbourne Technical College, 124 Latrobe Street, Melbourne, Australia.

Przegl. tech.—Przeglad Techniczny; semimonthly; Czasopismo Póswiecone Sprawom Techniki Przemyslu, ul. Piotrkowska Nr. 50, Lodz, Poland.

Publ. int. Ass. Bridge Struct. Engng.—Publications of the International Association for Bridge and Structural Engineering; annually; Verlag Ag. Gebr. Leeman & Company, Stockerstrasse 64, Switzerland (in English, German, or French, with summaries in the other two languages).

Publ. tech. Univ. Budapest (Müegyetemi Közl.)—Publications of the Hungarian Technical University (Müegyetemi Közlemenyek); irregular; Mérnöki Továbbképzö Intézet Kiádasa, 112 Müegyetem, Budapest XI, Hungary (in English, German, or French with Hungarian summaries).

Public Rds.—Public Roads; quarterly; Superintendent of Documents, Government Printing Office, Washington 25, D. C., U.S.A.

Q

Quart. appl. Math.—Quarterly of Applied Mathematics; quarterly; Brown University, Providence 12, Rhode Island, U.S.A.

Quart. J. Math.—Quarterly Journal of Mathematics, Oxford Series; quarterly; Geoffrey Cumberlege, Oxford University Press, Amen House, London E C 4, England.

Quart. J. Mech. appl. Math.—Quarterly Journal of Mechanics and Applied Mathematics; quarterly; Clarendon Press, Oxford, England.

Quart. J. roy. met. Soc.—Quarterly Journal of the Royal Meteorological Society; quarterly; Royal Meteorological Society, 49 Cromwell Road, London S W 7, England.

R

R. C. Accad. Lincei—Atti della Accademia dei Lincei, Rendi-Conti; monthly; Dott. Giovanni Bardi, Tipografo dell'Accademia Nazionale dei Lincei, Salita dei Crescenzi 16, Rome, Italy.

R. C. Mat. Appl.—Rendiconti di Matematica e delle Sui Applicazioni; irregular; Direttore dell'Istituto di Matematica della Università di Roma, Rome, Italy.

R. C. Semin. Mat. Univ. Padova—Rendiconti del Seminario Matematico della Universita Padova; semiannually; Casa Editrice Dott. Antonio Milani, Via Jappelli 5, Padova, Italy.

Rech. aéro. Paris—La Recherche Aéronautique; bimonthly; Office National de Études et de Recherches Aéronautiques, 3 Rue Leon Bonnat, Paris XVI, France.

Refrig. Engng.—Refrigerating Engineering; monthly; The American Society of Refrigerating Engineers, 40 W. 40th Street, New York 18, New York, U.S.A.

Rep. Inst. Sci. Technol. Tokyo—Reports of the Institute of Science and Technology; monthly; Institute of Science and Technology, University of Tokyo, 856 Komabacho, Meguro-ku, Tokyo, Japan.

Research Lond.—Research; monthly, 19-23 Ludgate Hill, London E C 4, England.

Rev. Col. Ing. Venezuela—Revista del Colegio de Ingenieros de Venezuela; bimonthly; Edificio del Colegio de Ingenieros, En El Parque de los Caobos, Apartado de Correos 2006, Caracas, Venezuela, S. A. (in Spanish).

Rev. gén. Hyd.—Revue Générale de l'Hydraulique; bimonthly; 116 Avenue d'Orléans, Paris XIV, France.

Rev. Matér. Constr.—Revue des Matériaux de Construction et de Travaux Publics; monthly; Société d'Éditions Scientifiques Techniques et Artistiques, 75 rue Lafayette, Paris 9, France.

Rev. Métall.—Revue de Métallurgie; bimonthly; 5 Cité Pigalle, Paris 9, France.

Rev. mod. Phys.—Reviews of Modern Physics; quarterly; Ameri-

can Institute of Physics, 57 E. 55th Street, New York 22, New York, U.S.A.

Rev. Opt. (théor. instrum.)—Revue d'Optique (Théorique et Instrumentale); monthly; 3 & 5 Blvd. Pasteur, Paris 15, France.

Rev. sci. Instrum.—Review of Scientific Instruments; monthly; American Institute of Physics, 57 E. 55th Street, New York 22, New York, U.S.A.

Rev. stiint. Adamachi—Revista Stiintifică "V. Adamachi"; quarterly; Laboratorul de Chimie Organica, Universitatea din Iasi, Iasi, Roumania.

Rev. tehn. AGIR Chim. Bucarest—Revistele Tehnice AGIR Chimie; bimonthly; Asoc. Generala a Inginerilor din Romania, Str. Romana 8, Bucaresti, Roumania.

Rev. tehn. AGIR Constr. Bucarest—Revistele Tehnice AGIR Constructii; bimonthly; Asoc. Generala a Inginerilor din Romania, Str. Romana 8, Bucaresti, Roumania.

Rev. tehn. AGIR Elect. Bucarest—Revistele Tehnice AGIR Electricitate; bimonthly; Asoc. Generala a Inginerilor din Romania, Str. Romana 8, Bucaresti, Roumania.

Rev. tehn. AGIR Metalul Bucarest—Revistele Tehnice AGIR Metalul; bimonthly; Asoc. Generala a Inginerilor din Romania, Str. Romana 8, Bucaresti, Roumania.

Rev. tehn. AGIR Min. Bucarest—Revistele Tehnice AGIR Mine; bimonthly; Asoc. Generala a Inginerilor din Romania, Str. Romana 8, Bucaresti, Roumania.

Rev. tehn. AGIR Petrol Bucarest—Revistele Tehnice AGIR Petrol; bimonthly; Asoc. Generala a Inginerilor din Romania, Str. Romana 8, Bucaresti, Roumania.

Rev. tehn. AGIR Textile Bucarest—Revistele Tehnice AGIR Textile; bimonthly; Asoc. Generala a Inginerilor din Romania, Str. Romana 8, Bucaresti, Roumania.

Rev. tehn. Comun. Lucr. Publice—Revista Tehnica Comunicatii si Lucrări Publice; irregular; Ministerul Lucrarilor Publice, Str. Gutemberg Nr. 3 Etaj IV, Bucaresti, Roumania.

Rev. univ. Min.—Revue Universelle des Mines, de la Métallurgie des Travaux Publics; monthly; Association des Ingénieurs Sortis de l'École de Liège, 12 Quai Paul van Hoegaerden, Liège, Belgium (in French).

Riv. aero.—Rivista Aeronautica; monthly; Associazione Culturale Aeronautica, Piazza del Popolo 18, Roma, Italy.

Riv. maritt.—Rivista Marittima; monthly; Via S. Andrea della Fratte 1, Roma, Italy.

S

SAE Quart. Trans.—see Soc. auto. Engrs. quart. Trans.

Schweiz. Arch.—Schweizer Archiv für Angewan dte Wissenschaft und Technik; monthly; Buchdruckerei Vogt-Schild A.G., Solothurn, Switzerland (in French or German).

Schweiz. Bauztg.—Schweizerische Bauzeitung; weekly; S.I.A. Schweizerischer Ingenieur- und Architekten-Verein, Postfach, Zurich 39, Switzerland (in German).

Schweiz. Verb. MatPrüf. Tech. Ber.—Schweiz. Verband für die Materialprüfungen der Technik Bericht; irregular; Eidgenössische Materialprüfungs- und Versuchsanstalt für Industrie, Bauwesen und Gewerbe, Zurich, Switzerland (in French or German).

Sci. Rep. Nat. Tsing Hua Univ. Ser. A Math. Phys. Engng. Sci.—Science Reports of the National Tsing Hua University, Series A Mathematical, Physical and Engineering Sciences; semiannually; Office of Publication, National Tsing Hua University, Peiping, China (in English or French).

Shipbuilder—Shipbuilder and Marine Engine-Builder; monthly; Shipbuilder Press, Townsville House, 10 Cartington Terrace, Newcastle-upon-Tyne 6, England.

Soc. auto. Engrs. J.—Society of Automotive Engineers Journal; monthly; Society of Automotive Engineers, 29 W. 39th Street, New York 18, New York, U.S.A.

Soc. auto. Engrs. quart. Trans.—Society of Automotive Engineers Quarterly Transactions; quarterly; Society of Automotive Engineers, 29 W. 39th Street, New York 18, New York, U.S.A.

Sulzer tech. Rev.—Sulzer Technical Review; irregular; Sulzer Brothers Ltd., Winterthur, Switzerland (in English).

Svenska TraforskInst. Medd.—Svenska Traforskninginstitutet Tratekniska Avdelningen Meddelande; irregular; Swedish Forest Products Research Laboratory, Wood Technology Dept., Drottning Kristinas vag 67, Stockholm O, Sweden.

Swedish Cem. Concr. Res. Inst.—Swedish Cement and Concrete Research Institute Publications; irregular; Royal Institute of Technology, Stockholm, Sweden (in Swedish with English summaries or English).

T

Tech. mod.—Technique Moderne; monthly; Editeur Dunod, 92 rue Bonaparte, Paris 6, France.

Tekn. Skr.—Tekniska Skrifter; irregular; Svenska Teknologföreningen, Kungsgatan 37, Stockholm C, Sweden (in Swedish with English summaries).

Tekn. Tidskr.—Teknisk Tidskrift; weekly; Svenska Teknologföreningen, Kungsgatan 37, Stockholm C, Sweden.

Trans. Amer. geophys. Un.—Transactions of the American Geophysical Union; bimonthly; General Secretary, American Geophysical Union, 1530 P Street, Washington 5, D. C., U.S.A.

Trans. Amer. Inst. min. metall. Engrs.—Transactions of the American Institute of Mining and Metallurgical Engineers; annually; American Institute of Mining and Metallurgical Engineers, 29 W. 39th Street, New York 18, New York, U.S.A.

Trans. Amer. math. Soc.—Transactions of the American Mathematical Society; bimonthly; American Mathematical Society, 531 W. 116th Street, New York 27, New York, U.S.A.

Trans. Amer. Soc. mech. Engrs.—Transactions of the American Society of Mechanical Engineers; eight issues per year; American Society of Mechanical Engineers, 29 W. 39th Street, New York 18, New York, U.S.A.

Trans. Amer. Soc. Metals—Transactions of the American Society for Metals; semiannually; American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio, U.S.A.

Trans. Chalmers Univ. Technol.—Transactions of Chalmers University of Technology; irregular; Gumperts Forlag, Göteborg, Sweden (in Swedish with English summaries, German or English).

Trans. Inst. mar. Engrs.—Transactions of the Institute of Marine Engineers; irregular; Institute of Marine Engineers, 85 Minories, London E C 3, England.

Trans. Instn. Engrs. Shipb. Scot.—Transactions of the Institution of Engineers and Shipbuilders in Scotland; seven issues per year; Institution of Engineers & Shipbuilders in Scotland, Elmbank Crescent, Glasgow, Scotland.

Trans. Instn. nav. Archit. Lond.—Transactions of the Institution of Naval Architects; annually; Institution of Naval Architects, 10 Upper Belgrave Street, London S W 1, England.

Trans. N. E. Coast Instn. Engrs. Shipb.—Transactions of the North East Coast Institution of Engineers and Shipbuilders; monthly; North East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne, England.

Trans. roy. Inst. Technol. Stockh.—Transactions of the Royal

Institute of Technology; irregular; Kungl. Tekniska Hogskolans Bibliotek, Stockholm 26, Sweden (in Swedish or German with English summaries or English).

Trans. roy. Soc. Can. Sec. 3—Transactions of the Royal Society of Canada, Section III Chemical, Mathematical and Physical Sciences; annually; Royal Society of Canada, Ottawa, Ontario, Canada.

Trans. roy. Soc. Can. Sec. 4—Transactions of the Royal Society of Canada, Section IV, Geological Sciences Including Mineralogy; annually; The Royal Society of Canada, Ottawa, Ontario, Canada.

Trans. Soc. mech. Engrs. Japan—Transactions of the Society of Mechanical Engineers of Japan; irregular; Society of Mechanical Engineers of Japan, no. 561 Marunouchi Building, Tokyo, Japan.

U

Univ. Ill. engng. Exp. Sta. Bull.—University of Illinois Engineering Experiment Station Bulletin; irregular; University of Illinois, Urbana, Illinois, U.S.A.

Univ. Mich. Engng. Res. Inst. Rep.—University of Michigan Engineering Research Institute, Bumblebee Series Report; irregular; University of Michigan, Engineering Research Institute, Ann Arbor, Michigan, U.S.A.

W

Weld. Res. Suppl.—Welding Research Council of the Engineering Foundation Supplement; monthly; Welding Research Council, 29 W. 39th Street, New York 18, New York, U.S.A.

Welding Res. Supplement—see Weld. Res. Suppl.

Werkst. Betr.—Werkstatt und Betrieb; monthly; Carl Hanser Verlag, Leonhard-Eck-Str. 7, München 27, Germany.

Z

Z. angew. Math. Mech.—Zeitschrift für Angewandte Mathematik und Mechanik; monthly; Akademie-Verlag G.m.b.H., Chausseestr. 106, Berlin N 4, Germany.

Z. Phys.—Zeitschrift für Physik; bimonthly; Springer-Verlag OHG, Jebensstr. 1, Berlin-Charlottenburg 2, Germany.